A Study of Exchange Rate Modelling

by

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Abstract

This paper presents a study in the mainstream of exchange rate modelling.

The literature survey begins with an historical section, tracing the origins of many presently used principles and concepts to debates that started over two centuries ago. Literature on balance of payments determination is included as relevant to this survey. The elasticities, absorption, and monetary approaches are presented as three basic models which have often served as skeletons on which recent attempts at modelling exchange rates have been built. Various individual components or aspects of exchange rate modelling are then discussed--components such as expectation formation assumptions, stock and flow effects, and flexibility of prices, which can be manipulated to transform one of the three basic models into one of the other two, or to extend one of the basic models into a new model. The dynamics involved in exchange rate modelling are considered, laying the groundwork for a later chapter. Finally, empirical work on exchange rate models is briefly summarized.

In the three central chapters, empirical versions of the monetary, Dornbusch, and stock-flow type models are developed and econometrically tested using a sterling effective exchange rate and data for the United Kingdom and its major trading partners. In cases for which more than one set of data is arguably appropriate for a given variable used in estimation (for instance, M1, M3, or sterling M3 might be the appropriate money supply measure to use in regression) the sensitivity of the estimation to the data set used is studied. On the basis of Sargan's test for common factors, all three models show signs of dynamic misspecification (though for the stock-flow model that conclusion is seen to depend on the data set used). Both graphical methods and two different F-

tests provide evidence of structural breaks in estimations of all three models over the period studied. The log likelihood ratio and Davidson and MacKinnon's non-nested tests are used to compare the three models and to compare various estimations of each of the models.

The last main chapter of the text presents further discussion of the dynamics involved in exchange rate modelling. In particular, models displaying saddlepoint type stability (a popular aspect of recent modelling, especially rational expectations modelling) are considered in terms of realism of their underlying assumptions. The idea of structural stability or robustness is discussed as relevant to the issue of realism of saddlepoint type models.

Possible extensions of the present research are discussed in the conclusion.

Page Numbering as Bound

I hereby declare that this thesis was composed by myself, and that the work contained herein is, except where otherwise acknowledged, my own.

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Introduction

Introduction

Worldwide international economics has become increasingly complex, but also increasingly important, as economies of the world have become more integrated in the years since World War II. In the early post war years, the fixed exchange rates of the Bretton Woods system served the growing international economy well. But the exchange rate crises of the late sixties and early seventies led many to the conclusion that a floating exchange rate regime was necessary if such crises were to be avoided in the future. Implementation of this new regime brought with it new interest and importance for the exchange rate which has now moved to the forefront of international economic decisionmaking. As a result, research into the determinants of exchange rates now dominates research in international economics. For these and other reasons, international economics with the focus of exchange rates seems an interesting, important, and challenging field in which to work.

This paper represents a study in the mainstream of exchange rate modelling research. The first main chapter of the text (Chapter 2) provides a framework for this and other research by outlining and reviewing the literature relevant to exchange rate modelling. Ideas pertinent to balance of payments determination are presented as relevant since many of the same forces and pressures that influence the exchange rate in a floating rate regime will instead affect the balance of payments in a fixed rate regime. The survey traces the origins of many presently used principles and concepts to the writings of David Hume, Isaac Gervaise, David Ricardo, and others taking part in debates that started over two centuries ago. The elasticities, absorption, and monetary approaches are then discussed as representing three fundamental models that are commonly built upon or extended in recent attempts at modelling exchange rates.

Several components or aspects of exchange rate modelling such as expectation formation assumptions, the degree of sophistication of asset markets, and stock and flow effects are then discussed. These and other building blocks of modelling can be altered to transform one of the three fundamental models into either of the other two, or to extend any of the basic models to create new models. The dynamics involved in exchange rate modelling are then discussed, setting the stage for Chapter 6 which focuses on dynamics. Chapter 2 concludes with a brief overview of empirical work on exchange rate models. Such studies are seen to be relatively few and largely lacking in rigour.

Chapters 3, 4, and 5 represent contributions to the body of empirical work on exchange rate modelling. Empirical versions of the monetary, Dornbusch, and stock/flow type models are formulated and econometrically tested using a sterling effective exchange rate and data for the United Kingdom and its major trading partners over the period January, 1972 through February, 1980. Where more than one set of data is arguably appropriate (for instance, M1, M3, or sterling M3 might be appropriate as the domestic money supply measure to be used in regression) the estimation is tested for sensitivity to the data set used. Sargan's test for common factors is used to test for signs of dynamic misspecification in the three models, and graphical methods and two different F-tests are used to check for structural breaks. The three models are quantitatively compared using log likelihood ratios and Davidson and MacKinnon's tests for non-nested models.

Chapter 6 represents a methodological break from the three previous, largely positive, chapters, focusing on the theoretical appeal of rational expectations models that use the saddlepoint/jump variable dynamic formulation. The break is justified on the grounds that any "true" model should have theoretical and intuitive appeal as well as being consistent with empirics, and that the former may be the better basis on which to develop new models. The idea of robustness or structural stability is discussed in the context of saddlepoint type models and their realism.

Finally, Chapter 7 summarizes and indicates some possible extensions of the work presented in this paper.

Review
of the
Literature

I. Introduction

In this chapter I shall make an attempt to summarize the progress made to date in understanding the movements of international exchange rates.

It is important to note that before floating exchange rates became common in the 1970's much of the literature assumed fixed exchange rates and focused on movements in the Balance of Payments (BOP). Under freely floating rates the BOP will always be zero since the exchange rates will move to insure that current and capital account imbalances are offsetting (assuming errors & omissions are zero). Under fixed rates, however, exchange rates are unable to move to relieve pressure and a non-zero BOP can exist and persist. Thus the BOP literature that predominated during the fixed rate period prior to the present float--and, indeed, has historically dominated the literature in this area--can, in general, be translated into floating rate terms. The BOP literature is therefore an important part of the literature relevant to the understanding of exchange rate movements. This relationship was seen as early as the time of David Ricardo (1817, p.151) who wrote:

> "If a country used paper money not exchangeable for specie, and, therefore, not regulated by any fixed standard, the exchanges in that country might deviate from par in the same proportion as its money might be multiplied beyond that quantity which would have been allotted to it by general commerce, if ... the precious metals had been used."

Throughout this paper I shall speak of various approaches to the balance of payments or exchange rate movements, referring to the fixed and flexible exchange rate cases, respectively.

It might be argued that virtually all of economics should be considered and studied when attempting to study exchange rate movements or the BOP. Even more than in most other fields of research, the extent to which another area of economics--say labor economics, growth economics, or price theory--is included in the study is arbitrary and must be based on the time constraints of the study. Anything that affects the current account or the capital account is relevant. Labor economics (the mobility of labor--especially across countries--,the extent of money illusion, the propensity to strike, the productivity of labor, the education level and ability of labor to learn) is important mostly in its affect on the current account. Politics (the extent to which a given party or leader in power is seen as generally good or bad for the economy and country, tightening or loosening of export, import, and/or capital flow controls by a government, the extent to which political instability propagates fears that investments in the country will be defaulted) can affect both the current and capital accounts. The degree of international capital mobility, the extent to which the assets of various countries are seen as substitutes, and the presence of one or more vehicle currencies can have effects mostly through the capital account. The theory of the firm (production functions used, productivity achieved, whether firms are manager or owner operated, accounting principles used, especially where multinationals are involved) can affect both the current and the capital accounts. Economics of natural resources (the affect of weather on tourist trade, the dependence on oil and/or other raw materials as either imports or as exports) comes into play mostly through the current account. The list could go on for many pages. For each of the components of that list, the dynamics of its influence on the current and/or capital account would need to be considered. Virtually any of the diverse fields of study in economics is argueably relevant in the understanding of exchange rate movements. Indeed, any particular area might be critical in explaining those movements for a given country over a given time period. In general, if a model is to facilitate understanding, it must be represent a simplified version of the real world, not a mirror of it. The generally critical explanatory components should be included in the basic model and then specifically critical explanatory components added in only when they are warranted.

Such has been the development of the floating exchange rate and BOP literature: the mainstream of contributors to the area developing models with more or less universal characteristics and applicability, and specialists from other areas of economics creating more specialized models to point out the relevance of their specialty to the determination of exchange rates or the BOP.

This chapter will follow an outline which seems indicated by the way this literature has developed. Section II will present pre-Keynesian historical contributions toward understanding movements in the BOP and exchange rates. As already noted, the historical emphasis was on the BOP.*

Sections III, IV and V will present respectively the elasticities, absorption, and monetary approaches to the BOP or exchange rate determination. These approaches indicate the three general model types that have dominated the recent literature in this area. Although these three models are commonly referred to in the literature, their exact specifications are difficult to identify since the approaches seem to mean slightly

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*More accurately the emphasis was on the Balance of Trade since evolution of present day sophisticated international capital markets is a relatively recent development. With investment across country borders at an insignificant level and trade in invisibles also minimal, the BOP was reduced the BOT.

different things to different people. I will attempt to specify the barebones versions of these models, including only those aspects that are critical.

Section VI discusses several extensions of exchange rate or BOP modeling that have been studied in the recent literature. In some cases what is an extension to one of the general models is actually a component of one of the other general models. In these cases extensions of the general models serve to blur the line separating the general approaches, creating models that are hybrids of two or all of the models presented in sections III, IV, and V. Most of the extensions, however, lead to specialized models that are relevant and applicable only under a specific set of circumstances, such as the small country setting, steady state inflating, or oil exporting country setting.

Section VII gives a brief discussion of the dynamics involved in exchange rate or BOP modeling.

Finally, section VIII presents a survey of empirical work on exchange rate determination from studies on exchange rate market efficiency and volatility to econometric studies testing and comparing some of the models and characteristics presented in the preceding sections.

II. Pre-Keynesian Contributions Towards Understanding Movements in the BOP or Exchange Rates*

Many of the concepts and controversies that dominate modern discussion of exchange rate determination have their roots in debates that began more than two hundred years ago. In this section I will present some of the ideas elucidated in those historical debates, as they provide a foundation for the discussion of the more recent literature that follows this section.

A. Natural Distribution of Species or Money

One of the earliest and simplest concepts to be stated and used by those working in the area of international trade was that there existed some natural equilibrium distribution of the world money stock (actually of the money stock of trading nations) which, if disturbed, would restore itself over time. One of the first to set down this idea of a natural distribution, regarded almost as a law of nature, was Isaac Gervaise, who in 1720 (taken from Frenkel and Johnson, p.35) wrote of species: "A Nation cannot retain more than its natural Proportion of what is in the the world and the Balance of Trade must run against it."

In 1752, David Hume (taken from Frenkel and Johnson, p.36) wrote: "Suppose twenty million was brought into Scotland ... how much would remain in the quarter of a century? Not a shilling more than we have at present." It is interesting to note that Hume, though adamant that restoration of the natural distribution of species would take place, allowed a quarter of a century for that

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*This section owes much to useful reviews of this historical literature that are found in Frenkel and Johnson (76 pp.21-43), Iverson (67 pp.199-258) and Humphrey (82), among others.

restoration. Precipitating Hume's numerous statements of the natural distribution theory was the Mercantilist contention that a nation could become richer and more powerful by perpetually running a BOP surplus. Starting with the idea of natural distribution of species, Hume developed his price-specie flow analysis, discussed in more detail below, to show that it was impossible for a nation to perpetuate a BOP surplus and thereby retain more than its natural share of the world supply of species.

In 1821, it was David Ricardo (taken from Frenkel and Johnson, p.35) who wrote:

> "Gold and Silver having been chosen for the general medium of circulation, they are, by the competition of commerce, distributed in such proportions amongst the different countries of the world as to accommodate themselves to the natural traffic."

Although the precise mechanism may not have been clear, the idea of natural distribution of species was certainly present. John Stuart Mill combined the idea of a natural distribution of species or money with the idea of the neutrality of money when he wrote (taken from Frenkel and Johnson, p.36):

> "A newly acquired stock of money would diffused itself over all countries until money has diffused itself so equally that prices had risen in the same ratio in all countries, so that the alteration of price would be for all practical purposes ineffective."

Finally, Hawtrey's statement (taken from Frenkel and Johnson, p.37) that, until its effects can be distributed among the countries of the world, "an expansion of credit (in one country) causes an unfavorable balance of payments (in that country)", testifies that some sort of natural distribution of money theory was part of BOP or exchange rate analysis until the time of Keynes.

B. Real and Monetary Sources of Pressures on the BOP or Exchange Rates

With so many classical writers espousing the natural distribution theory it is logical that some of those writers should inquire into the possible mechanisms by which this natural distribution occured and was restored after a disturbance to the system. David Hume was one of the first to offer such a mechanism in his "Essay of the balance of trade" in which the following classic analysis appears (taken from Iverson, p.210):

> "Suppose four-fifths of all the money in Great Britain to be annihilated in one night ... what would be the consequence? Must not the price of all labour and commodities sink in proportion...? What nation could then dispute with us in any foreign market, or pretend to navigate or to sell manufactures at the same price, which to us would afford sufficient profit? In how little time, therefore, must this bring back the money which we had lost and raise us to the level of all the neighbouring nations? Where, after we have arrived, we immediately lose the advantage of the cheapness of labour and commodities; and the farther flowing in of money is stopped by our fulness and repletion ... It is evident that the same causes which would correct these exorbitant inequalities, ... must prevent their happening in the common course of nature, and must forever, in all neighbouring nations, preserve money nearly proportionable to the art and industry of each nation."

This price-specie flow analysis of Hume's clearly states a process by which a monetary shock to the system would be accomodated and the nature distribution restored. The analysis implies some version of the quantity theory of money, emphasising price adjustment as a critical aspect of re-equilibration (an emphasis that will be discussed in more detail below).

But about the time of Hume's writing, a debate was going on in Sweden over whether it was real or monetary shocks that created international payments imbalances or pressures on the exchange rate. In a fairly polar debate, the Hat political party argued that non-monetary causes were behind the depreciation of the Swedish mark and that the only solution was adoption of policies to promote exports and reduce imports. The Cap party, on the other hand, pointed to the overissue of notes by the Riksbank as the cause of the mark's depreciation, using analysis akin to that of Hume.

A British version of the real vs monetary debate took place after the Bank of England suspended convertability of banknotes into gold during the Napoleonic wars. The Bullionists clarified the quantity theory of money and purchasing power parity (discussed in more detail below) as tools to argue that, under inconvertability, the exchange rate varies in proportion with the quantity of money in circulation. The Antibullionists, like the Hats in the Swedish debate, argued that domestic inflation and depreciation of the exchange rate was a result of real disturbance such as crop failures or excessive military expenditure abroad and had nothing to do with the amount of money in circulation. In arguing the latter, the Antibullionists used the Real Bills Doctrine which says that overissue of currency can not occur as long as money creation is limited to the value of bills of exchange on real transactions in goods and services.

The hard-line Bullionists such as Ricardo and Wheatley rejected the view that real disturbances could cause depreciation of the pound, arguing that the smallest real pressure on the pound would make British goods and services enough cheaper to foreigners to increase exports and eliminate that pressure. They believed this adjustment took place almost instantaneously and so real causes could not be used to explain exchange rate depreciation even in the short run.

There were, however, some more moderate Bullionists, among them William Blake and Henry Thornton, who held that, while long run depreciation of the exchange rate could only result from excessive money creation, real factors could affect the exchange rate in the short run. Thornton used analysis similar to Hume's price-specie flow analysis to show how a real shock could affect the exchanges or the BOP (taken from Iverson, p.211):

> "At the time of a very unfavourable balance (produced, for example, through a failure of the harvest), a country has occasion for large supplies of corn from abroad; but either it has not the means of supplying at the instant a sufficient quantity of goods in return, or, ... the goods which the country having the unfavourable balance is able to furnish as means of canceling its debt, are not in such demand abroad as to afford the prospect of a tempting or even of a tolerable price ... The country, therefore, which has the favourable balance, being, to a certain degree, eager for payment, but not in immediate want of all the supply of goods which would be necessary to pay the balance, prefers gold as part, at least, of the payment; for gold can always be turned to a more beneficial use than a very great overplus of any other commodity. In order, then, to induce the country having the favourable balance to take all its payments in goods, and no part of it in gold, it would be requisite not only to prevent goods from being very dear, but even to render them excessively cheap ... For this reason it may be the true policy and duty of the bank to permit, for a time, and to a certain extent, the continuance of that unfavorable exchange, which causes gold to leave the country, and to be drawn out of its own coffers..."

Here Thornton argues that an increased demand for imports (corn from abroad) must be paid for either with gold (an export of specie) or by increasing exports of goods--which foreigners only demand in greater supply if those good's prices are lowered.

Ricardo took isssue with Thornton's view that real shocks could affect the exchange rate or BOP, writing (taken from Iverson, p.212):

> "Mr. Thornton has not explained to us why any unwillingness should exist in the foreign country to receive our goods in exchange for their corn; and it would be necessary for him to show, that if such an unwillingness were to exist, we should agree to indulge it so far as to consent to part with our coin."

But in a later edition of the same paper, he softened his view, admitting that a real shock could have an effect if it reduced (or increased) the amount of money demanded, setting the Humean type mechanism in motion (taken from Iverson, p.214):

> "If the circulating medium of England consisted wholly of the precious metals, and were a fiftieth part of the value of the commodities which it circulated .. (and if) England, in consequence of a bad harvest, would come under the case mentioned of a country having been deprived of a part of its commodities, and therefore requiring a diminished amount of circulating medium, (the) currency, which was before equal to her payments, would now become superabundant, and relatively cheap, in the proportion of one fiftieth part of her diminished production; the exportation of this sum, therefore, would restore the value of her currency to the value of the currencies of other countries."

Ricardo's mechanism by which a real shock is translated into international gold flows is wholly different from Thornton's. In the former case gold flows work to equilize demand and supply for domestic money while in the latter case gold flows work to equilibrate international goods markets.

Although he saw a role for real factors in determining exchange rates in the short run, Thornton was considered a Bullionist because he also saw a role for money and, as already mentioned, believed that only money was important in long run determination of the exchange rate. Indeed, it was Thornton who exposed the flaw in the real bills doctrine, pointing out that once prices started rising, they would legitimise creation of an ever-increasing volume of bills (and therefore money) to finance a constant volume of real transactions.

A third debate over the causes of payments imbalances or exchange rate movements occurred in Germany after the First World War. Gustav Cassel led the Monetarists who used the Purchasing Power Parity doctrine (the name which Cassel gave it) and the quantity theory of money to argue that excessive credit creation caused rising prices which caused the exchange rate to depreciate. The monetary school brought expectations into the analysis to explain why the mark was depreciating at a rate greater than the growth of the money supply. They argued that due to speculation, anticipations of depreciation in the future caused the mark to depreciate more than the level of money supply growth would indicate. M.J. Boon led the BOP theorists who argued that demands for Germany's imports and exports were both price inelastic and that fact, coupled with the burden of Germany's post-war reparation payments, accounted for the falling value of the mark. These BOP theorists argued that causality went from the exchange rate to the level of the money supply as follows: a depreciating exchange rate meant imported inflation which meant government budget deficits (since government expenditures were largely fixed in real terms but government revenues were mostly fixed in nominal terms) which necessitated an increase in the money supply.

So the present debates over the extent to which real and monetary factors determine exchange rates or the BOP have their roots in, and owe many of their tools and methods of analysis to, debates that took place as much as two hundred years ago.

C. The Purchasing Power Parity Doctrine

As a tool developed in these early debates, the doctrine of Purchasing Power Parity (PPP) deserves special attention. Also referred to as the international law of one price, this doctrine, named PPP by Gustav Cassel, was first made into an organized arguement by Henry Thornton in 1802. In his "The Paper Credit of Great Britain," Thornton clearly laid down the following causal chain. An increase in the supply of domestic money, he argued, would lead to an increase in the domestic price level, which, assuming a parallel inflation had not take place abroad, would make domestic goods more expensive relative to foreign goods. By increasing the demand for imports and decreasing the demand for exports this relative price change would lead to decreased demand for the domestic currency relative to the foreign currency. Under floating exchange rates, a depreciation of the domestic currency to an extent that exactly offset the change in relative prices would follow, returning the system to equilibrium. As mentioned in the last section, Thornton believed that only monetary phenomena could affect the exchange rate or BOP in the long run. He argued that in the long run under floating rates only the above causal chain was operative and therefore, that in the long run real relative prices (the foreign price level times the exchange rate divided by the domestic price level) were constant. This was later identified by Cassel as the relative version of PPP, which is represented by $S = k\ (P_f/P)$, where S is the exchange rate (foreign/domestic currency terms), P_f and P are the foreign and domestic price levels, respectively, and k is a constant. This has a special case, the absolute version, which calls for real relative prices, or equivalently, k in the above equation, to be equal to unity. Relative PPP allows that prices are not necessarily equalized across countries, but that once their ratio is established it will stay constant over time.

John Wheatley, already identified as a more hard line monetarist than Thornton, adapted Thornton's PPP analysis to a more hard line view, arguing that absolute PPP held in the short run (recall that Wheatley and Ricardo believed that real factors could not affect the exchange rate or the BOP even in the short run.) In asserting that the exchange rate (taken from Humphrey, p.153)

> "is exclusively governed by the relative state of prices, or the relative value of money, in the different countries between whom it is negotiated,"

Wheatley agreed with Thornton's views that real relative prices would not change over time and that exchange rate changes could not cause inflation. Rather, exchange rate changes were caused by inflation and prevented inflation from being transmitted abroad. The difference between Thornton and Wheatley was that Wheatley saw no role for real factors in determining the exchange rate even in the short run. Wheatley therefore contended that PPP held in the short run as well as the long run. Wheatley also believed that the real relative price level was determined without respect to any real phenomena, and was therefore equal to unity (absolute PPP.)

After the Bullionist debate was over, there was little development or refinement of PPP theory until the time of Cassel. Still, the basic concept of a law of one price was evident in Mill's statement (taken from Frenkel and Johnson, p.33) that, "By the fall, however, of cloth in England, cloth will fall in Germany also...By the rise of linen in Germany, linen must rise in England also" And again in the writings of Wicksell (taken from Frenkel and Johnson, p.33):

> "there could not possibly exist different prices of the same commodity on both sides of the frontier..., difference of prices in the two countries would be theoretically impossible and practically confined between very narrow limits."

But it was not until the German inflation controversy after WWI that Gustav Cassel extended and crystallized the analysis laid down by Thornton and Wheatley. As already mentioned, it was Cassel who gave this concept the name by which it is most commonly referred to, purchasing power parity (PPP), and identified its two forms: absolute PPP, in which the exchange rate is equal to "the quotient between the general levels of prices in the two countries", and relative PPP in which the exchange rate is calculated as "the old (exchange) rate multiplied by the quotient of the degree of inflation" in the two countries (both quotes taken from Humphrey, p.155). As implied by the wording of these definitions, Cassel was aware that it was two countries' <u>general</u> price levels (when put in terms of the same currency) whose ratio must stay constant and not relative price levels of individual goods as indicated above in statements by Mill and Wicksell. Further, Cassel pointed out that absolute PPP could only exist if the representative commodity baskets of the countries involved were identical.

Cassel restated the proposition of neutrality of exchange rate movements when he wrote (taken from Humphrey, p.155):

> "...the purchasing power parity represents an indifferent equilibrium of the exchanges in the sense that it does not affect international trade either way. Thus a country's export is not checked by low rates of exchange, provided only these rates correspond to a high price level abroad, or a low level at home; nor...is export particularly stimulated by high foreign exchange rates, so long as they only correspond to the relative purchasing power of the different currencies."

Implied in this quotation, and stated clearly many places in Cassel's writing, is the idea that causality runs from prices to exchange rates with prices being determined by the money supply via the quantity theory of money. Like Thornton and Wheatley, Cassel believed that inflation could not be imported from abroad--that it was solely the result of excessive domestic credit creation.

Finally, Cassel specified several reasons why PPP might not hold in the short run. First, there is the possibility of a speculative run against a currency for whatever reason--though he did cite expectations of a future depreciation resulting from expectations of future inflation as one possible reason for such speculation. As was mentioned in Section II.B., Cassel and his monetarist counterparts in the German inflation debate began to incorporate expectations into their analysis. Second, reparation payments such as those Germany was being forced to make after the First World War, or other transfers of currency at artificial prices could upset PPP in the short run. Third, inequality in the extent to which traded and non-traded goods prices responded to monetary shocks could keep PPP from holding in the short run. Finally, Cassel argued that random real disturbances such as crop failures, excessive military expenditure abroad, or appearance of an oil cartel could result in an exchange rate not consistent with PPP--but again, only in the short run. Whatever the disturbance, Cassel believed that PPP would be restored in the long run via the following stabilizing mechanism (taken from Humphrey, p.155):

> "As soon as a country's currency is undervalued compared with its purchasing power parity, it will be of peculiar advantage to buy this currency, and to employ the money thus obtained in procuring commodities from that country. This stimulus thus applied to demand will necessarily very soon raise the price of the currency to the level of the purchasing power parity."

At the same time Cassel was writing, Ludwig Von Mises was also doing work in this area and writing in support of the PPP doctrine--though Von Mises' writings did not rival Cassel's in terms of clarifying and developing the doctrine. Like Cassel, Von Mises stated that the exchange rate moved to equilize prices across countries, the PPP equilibrium was stable, and that causality in adjustment went from the money supply to the price level to the exchange rate.

D. Adjustment Through Changes in Absorption and/or Changes in Relative Prices

Frenkel and Johnson (p.37) have pointed out that the recent debates over the extent to which adjustments to international payments or exchange rate equilibrium take place via changes in absorption or changes in relative price levels (both approaches to be discussed in more detail below) also have their roots in the historical literature. We have already seen quotations from Hume, Thornton, Ricardo, and Mill laying down mechanisms in which price adjustment played a critical role in re-equilibration. But there is evidence that these and other classical writers also believed in mechanisms in which price adjustment played no part--in which BOP or exchange rate equilibrium was restored through non-price induced changes in the relationships between expenditure and income in the countries.

Richard Cantillon made no mention of changes in relative prices when in 1735, he wrote (taken from Frenkel and Johnson, p.38): "The increase in money will bring about an increase in expenditure..states which have acquired a considerable abundance of money ordinarily import many things from neighboring countries where money is scarce." But it is possible that he had no clear mechanism in mind when he wrote this. Hume, whose price-specie flow analysis clearly included changes in relative prices as part of a well worked out mechanism for adjustment, seemed to point to a second mechanism for affecting the BOP or the exchange rate when, in 1758 he wrote (taken from Frenkel and Johnson, p.38): "The inhabitants, having become opulent and skillful, desire to have every commodity in the utmost perception:...they make large importations from every foreign country." With the home country's exports assumed to be constant as these importations are increased, this quotation might be considered an early and crude statement of the absorption approach to the BOP.

Similarly, Mill--who along with Hume was one of the great classical price theorists--implicated alterations in the relationship between a country's income and its expenditure as an alternative to price adjustment when he wrote (taken from Frenkel and Johnson, P.39):

> "The English public, having more money, will have a greater power for purchasing foreign commodities... there will be an increase of imports; and by this, and the check to exportation, the equilibrium of imports and exports will be restored."

Finally, Wicksell argued in favor of the absorption approach in 1918 when he wrote (taken from Frenkel and Johnson, P.39):

"The stimulus to these altered conditions of trade is not be to found in a difference of prices in the two countries...the increased demand for commodities in one country, the diminished demand in the other, would in the main be sufficient to call forth the change alluded to."

Thus, the post-Keynesian debates over the extent to which adjustments to the BOP take place through changes in relative prices or through changes in absorption also find their roots in two centuries of historical literature.

E. Development of Capital Markets and Their Role in BOP and Exchange Rate Determination Analysis

As already mentioned, the early classical writers considered only the relationship between imports and exports of goods as determining pressures on a country's exchange rate or BOP. Through the time of Ricardo it was common to use the terms Balance of Trade aand Balance of Payments interchangeably. Any analysis focused on the effect of a given shock on the exchange rate or international payments balance via that shock's effects on international trade in goods to the exclusion of any capital flows that might result from the shock. In a large part this apparent lack of sophistication simply reflected the relative simplicity of the environment the early writers were observing; it was well into the 19th century before international capital markets existed on a scale to make international capital flows an important component of exchange rate or BOP analysis.

Not until 1848 did Mill write (taken from Frenkel and Johnson, p.35) that "capital is becoming more and more cosmopolitan." He then expanded on that statement by presenting an alternative to the price-specie flow mechanism for restoring the natural international distribution of money, arguing (taken from Frenkel and

Johnson, p.37) that a domestic injection of twenty million pounds sterling "would create a sudden fall in the rate of interest, which would probably send a great part of the twenty millions of gold out of the country as capital." Others observed the same phenomenon, Bagehot writing (taken from Frenkel and Johnson, p.35) that "A cosmopolitan loan fund exists which runs everywhere as it is wanted, and as the rate of interest tempts it." Mill concluded (taken from Frenkel and Johnson, p.37) that

> "It is a fact now beginning to be recognized that the passage of the precious metals from country to country is determined much more than was formerly supposed, by the state of the loan market in the different countries, and much less by the state of prices."

As true as it may have been when he wrote it, this last statement by Mill seems particularly apt in light of the last ten years of study into the determinants of exchange rate movements. Models that include asset markets as having a critical influence on exchange rates have dominated the recent literature.

III. The Elasticities Approach

The elasticities approach to the BOP abstracts from capital movements and studies how changes in the relative prices of imported goods, exported goods, and in some cases--though not here--non-tradable goods, affect the value of imports and exports. Thus, the focal equation for the elasticities approach is BOP = BOT = X-M where, without capital movements (and also forgetting about trade in invisibles), the balance of payments reduces to the balance of trade which is equal to the same currency value of exports minus imports. Although this approach finds its origins in the work of Alfred Marshall, its development was a post Keynesian phenomena and as such, sticky prices are assumed. Flexible prices, which Marshall might have assumed, would have trivialized the analysis anyway, resulting in Purchasing Power Parity if relative price and exchange rate movements were always offsetting. Instead, with sticky prices, changes in the exchange rate are the only possible source of changes in prices of imports (in terms of the domestic currency) and exports (in terms of the foreign currency). The elasticities approach is therefore used to study the effects of depreciation or appreciation of the exchange rate on the BOP. The framework above is set up for analysis of a fixed exchange rate regime (or at least a regime in which exchange rates are not allowed to float cleanly) which was, of course, the order of the day in the post-WWII Bretton Woods environment. The elasticities approach can, however, be applied to a world of flexible exchange rates by setting BOP=BOT=0 in the above equation. Thus, the approach is used to identify the exchange rate that will keep imports equal to exports at every point in time.

In any case, the elasticities approach involves more than just multiplying a fixed real volume of imports and exports by their respective price levels. Joan Robinson made this point in her essay on "The Foreign Exchanges" when she wrote (taken from Meier, p.166):

> "Suppose that, after a certain exchange rate has been in force for some time, the amount which the inhabitants of the home country desire to lend abroad increases. At the ruling exchange rate the demand for foreign currency exceeds the supply and the exchange rate consequently falls. This has the effect of making home-produced goods appear cheaper to foreigners and so increasing the volume of exports. If the physical volume of exports increases their home price cannot fall, therefore the value of exports in terms of home currency must increase. But the effect on imports is more complicated. Foreign goods are now dearer at home, and while the physical volume of imports purchased out of a given income will decline, total expenditure upon them may increase the balance of trade. If the value of imports (reckoned in home currency) increases by more than the value of exports, then a fall in the exchange rate will reduce the balance of trade.
>
> The argument may be treated in terms of four elasticities: the foreign elasticity of demand for exports, and the home elasticity of supply (which is influenced by the home elasticity of demand for exportable goods), the foreign elasticity of supply of imports and the home elasticity of demand for imports (which is influenced by the home elasticity of supply of rival commodities)."

Thus, it is not only changes in the prices of imports and exports that affect the BOP, but the way those changes in prices affect the real volumes of exports and imports supplied and demanded. In fact, as the name of the approach implies, it is the latter that is considered most important.

There is a simplified statement of this relationship between elasticities and the BOT which comes out of Alfred Marshall's "Money, Credit and Commerce" and Abba P. Lerner's "The Economics of Control". This Marshall-Lerner condition says that, assuming infinite supply elasticities, and assuming that BOT=0 initially, the international trade system will be unstable if the (absolute values of the) demand elasticities for a country's exports and imports sum to less than unity. The manifestation of instability in this system would be when depreciation (or appreciation) of a currency begets further depreciation (appreciation) of that same currency, starting a never ending chain of depreciations (appreciations). A positive BOT would put pressure on a currency to appreciate while a negative BOT would create a tendency toward depreciation. Thus the Marshall-Larner condition may be restated as a relationship between demand elasticities and the BOT: depreciation will result in worsening of a country's BOT if the demand elasticities for that country's imports and exports sum to less than unity. Likewise, if those demand elasticities sum to more than one, then depreciation will strengthen a country's BOT and the system will tend to move back toward the pre-depreciation equilibrium where BOT=0. Finally, if those demand elasticities sum exactly to one then depreciation will land the system on a new equilibrium in which BOT=0. In this last case, the system will be stable not in the sense that after perturbation it adjusts to restore the original equilibrium (which is what would happen when demand elasticities sum to more than one) but in the sense that any state arrived at after perturbation is a new equilibrium.

A sort of dynamic hybridization of the stable (import and export demand elasticities sum to more than one) and unstable (demand elasticities sum to less than one) environments results in what is commonly referred to as a J-curve. Existence of this phenomenon requires that the system is stable in the long run, but that, due to transaction costs, forward contracting and other inertia inducing factors, the demands for a country's imports and exports are inelastic in the short run. Under these circumstances depreciation of a country's currency would result in a worsening of that country's BOT in the short run. But then, as contracts made on the basis of the old exchange rate are filled and long run elasticities take over, the long run effect of the depreciation would be to improve the BOT of the country whose currency depreciated, producing a graph that resembles a J (a J-curve) if the BOT is plotted over time.

There are three major shortcomings of the elasticities approach. First, this approach neglects the capital account. To the extent that capital flows are important in determining the BOP or the exchange rate, and through those variables affect the stability of the system, this is a serious oversight.

Second, as has also already been mentioned, this approach has its roots in the work of Marshall and uses partial equilibrium analysis. As such, cross elasticities and other interactions between sectors of the economics under study are neglected. This may or may not be a serious shortcoming, depending on the environment to which it is applied.

A third major shortcoming relates specifically to the Marshall-Lerner version of the elasticities approach, namely, that supply elasticities of imports and exports are assumed to be infinite. To the extent that this assumption is not realistic the Marshall-Lerner condition loses its significance.

The second of these shortcomings is addressed by the absorption approach presented in the next section. Inclusion of the capital account does not occur until Section V where the monetary approach is discussed.

IV. The Absorption Approach

As was mentioned in Section I, it is not really possible to identify a specific model as the one that is referred to when writers speak of the absorption approach. Strictly speaking, it was Sidney Alexander in his paper "Effects of a Devaluation on a Trade Balance" that coined the term, but the literature seems to refer to much of the Keynesian macroeconomics based contributions of Machlup, Alexander, Meade and others as falling under the heading of the absorption approach.

The central theme of the absorption approach was set down in Alexander's paper where he wrote (taken from Meier, p.176):

> "it is generally recognized that a country's net foreign trade balance is equal to the difference between the total goods and services produced in that country and the total goods and services taken off the market domestically."

Instead of the difference between exports and imports that is central to the elasticities approach, the absorption approach focuses on the difference between a country's real national income, Y, or domestic output, and its total national expenditure, E:

$$BOP = BOT = Y-E = X-M.$$

This equation points to the fact that an internal payments imbalance as measured by Y-E is simply a reflection of the country's external payments imbalance as measured by X-M.

The above equation reveals a further point about the absorption approach: like the elasticities approach, the absorption approach abstracts from capital movements, assuming that trade in goods dominates international payments and, as such, that the BOP reduces to the BOT.

As a practical point, Allen and Kenen (79) have argued in defense of this simplification, that capital flows were miniscule at the time the absorption approach was being formulated (a point which also may be made for the elasticities approach), and did not become large enough in volume to have much effect on the BOP until the 1960's. Whether abstraction from capital flows was warranted at the time the absorption approach was being formulated or not, however, this simplification must be considered a weakness if the approach is to be used in times that the BOP is arguably dominated by capital flows.

The absorption approach is often said to point to "expenditure-reducing" policies as the means by which an international payments deficit can be brought under control. As can be seen in the above equation, however, either expenditure reduction or expansion of output would lead to improvement of the balance of trade if that change in expenditure or income did not cause a more than offsetting change in the other to come about.

It is study of this possibility of an offsetting change (or more accurately, the study into the overall macroeconomic consequences of a change in expenditure or income) that dominated the early writings on what we are referring to here as the absorption approach. In the late 1930's and 1940's Metzler, Machlup and others developed and worked out the fine points of the foreign trade multiplier which was the open economy version of Keynes' multiplier.

In the open economy, as in the closed economy, equilibrium is obtained when injections into the economy equal leakages out of the economy. In addition to government expenditure, G, and investment, I, which can provide exogenous injections into the closed economy, exports, X,--which are exogenous if we assume the home country is small--may also provide injections into the open economy. Likewise, leakages from the open economy may be caused be imports, M, as well as the closed economy leakage sources, savings, S, and taxation, T. Thus, for the open economy, equilibrium is achieved when the following equation is satisfied:

$$G + I + X = T(Y) + S(Y) + M(Y).$$

The notation of this equation serves to remind us that all of the right hand side variables are assumed to depend on income.

Since we know that the above equation will hold at all equilibria, we can write an equation for the changes that occur between two equilibria as:

$$\Delta G + \Delta I + \Delta X = \Delta T(Y) + \Delta S(Y) + \Delta M(Y).$$

We can simplify this equation if we further identify the relationships between each of the right hand side variables and income:

$$\Delta T = t\Delta Y$$
$$\Delta S = s\Delta Y$$
$$\Delta M = m\Delta Y$$

Substituting these into the difference equation, we get

$$\Delta G + \Delta I + \Delta X = (t + s + m)\Delta Y.$$

The foreign trade multiplier (also called the open economy multiplier) is therefore

$$\frac{\Delta Y}{\Delta G} = \frac{\Delta Y}{\Delta I} = \frac{\Delta Y}{\Delta X} = \frac{1}{t + s + m}.$$

This multiplier describes the overall affect on income of an exogenous injection into the economy from one of the three left hand side variables, assuming that the other two left hand side variables are held constant. It involves the same types of simplifying assumptions used in the closed economy version: t, s, and m are assumed to be constant over time and over all levels of income, the effects of transfer payments and tariffs are assumed to be included in t, s, and m, etc.

That the multiplier impacts the effect of a change in net exports on income was understood and stated by Joan Robinson in her exposition of the elasticities approach. But in her case the multiplier effect came into play mostly in relation to the constraint that full employment income implied as to the solution paths available to the elasticities approach, instead of, as in the absorption approach, as a critial aspect and component of any solution paths. Yet this early version of the absorption approach, like the closed economy Keynesian model, assumed that income was not at the full employment level and was only really useful in helping to eliminate a BOT deficit if expansion of domestic income was possible. Keynes himself, writing (36, pp. 378-9) with respect to his ideas in the closed economy, made a point applicable also to the open economy application of his ideas when he wrote:"...if our central controls succeed in establishing an aggregate volume of output corresponding to full employment as nearly as is practicable, the classical theory comes into its own from this point onwards." Classical theory dealt with a special case, the full employment one, of Keynes' more general theory, and as such was applicable whenever full employment existed. Likewise, in the high employment post-WWII era, the open economy multiplier approach seemed out of its element and analysis turned to the neoclassical based elasticities approach.

As already mentioned, the latter was refined into a workable form by Robinson in 1951 and so chronologically was a successor to the open economy multiplier approach.

It was at this point that Alexander made his contribution, returning the analysis to the difference between income and expenditure, as opposed to the difference between exports and imports that was the focus of the elasticities approach. But he emphasized changes in expenditure or absorption as a way of affecting the BOT instead of emphasizing changes in income as the open economy multiplier approach had. Specifically, he wrote (taken from Meier, p.176):

> "Absorption then equals the sum of consumption (of both domestic and foreign goods) plus investment as usually defined (including in investment any change in the holding of inventories). If a devaluation is to affect the foreign balance, it can do so in only two ways: (1) It can lead to a change in the production of goods and services in the country; this change will have associated with it an induced change in the absorption of goods and services so that the foreign balance will be altered by the difference between the change in income and the income induced change in absorption. (2) The devaluation may change the amount of real absorption associated with any given level of real income."

The first case recognizes that each good has its own elasticity and demand curve and as such, when the portfolio of consumed goods is induced to change, the overall income level may change which may alter the level of absorption. As a result of the change in income and absorption the BOT may change--though it is not clear _a prior_ in what direction a devaluation would cause the BOT to move operating under this mechanism. Alexander's second mechanism is simply the real balance effect of the inflation associated with a devaluation and as such the direction of influence of a devaluation on the BOT as a result of this effect is predictable. A devaluation will reduce real balances, causing domestics to demand more money and therefore, spend or absorb less, making the difference between income and expenditure (absorption) become a larger number, improving the BOT.

Harry Johnson (77, EIF, p.10) pointed out a defect in Alexander's analysis, however, when he wrote:

> "...the absorption approach still concentrates on expenditure flows, not recognizing that a continuing deficit will eventually correct itself without devaluation by reducing the economy's real balances, unless real balances are continually renewed by domestic credit expansion to offset the effects of reserve losses (that is, unless a policy of sterilization is pursued--parenthesis added). In such a case, devaluation will not improve the balance of payments by deflating real balances."

Johnson's point is correct if authorities do not choose to or are unable to sterilize selectively--are unable to offset the effect of actual flows into and out of the country, while leaving the real balance effect of devaluation unchecked. If the authorities did sterilize selectively in this way, a trade deficit would not be self correcting and could be perpetuated. In any case, Alexander's second, real balance effect related mechanism would still be operative. As an empirical matter, Marina v. N. Whitman has reported (75, p.523) that the degree of realism involved in any assumption of sterilization level practiced depends on the country involved as some countries sterilize almost completely while other countries practice almost no sterlization. Sterilization is generally assumed to be practised in absorption type models.

In 1951, James Meade presented his two volume study entitled "The Balance of Payments" in which he developed normative instead of positive analysis, describing the policy instruments that authorities must control if they wish to effect high employment and a balance of international payments. In what has been considered by many a seminal work, Meade made great strides into the theory of simultaneous analysis of internal and external balance. He showed that authorities needed fiscal or monetary policy to control absorption by domestics and they needed control over the exchange rate or trade and payments restrictions in order to affect the composition of absorption between domestic and foreign goods toward that composition indicated by a zero BOP. Thus Meade's was really a synthesis of the elasticities and absorption approaches. In fact, by suggesting the possibility of a role for monetary policy, which was later expanded on by Mundell (62) and Flemming, (62) he was also in a way the father of the monetary approach to the BOP and exchange rate determination which will be discussed in the next section.

In Meade's work too Johnson takes issue with the way international payments are treated as flows without consideration of stock adjustment involved. As long as authorities are able to maintain internal and external equilibrium no problem results, but Johnson states (77, EIF, p.10):

> "Inconsistency could arise only from the implication that if government policy erred, the result would be a continuing flow-equilibrium deficit or surplus whose elimination would require a change in governmental economic policy."

But Isard (78, p.19) argues that Meade was aware of the need for consistency between the treatment of stocks and flows:

> "Strangely, Meade's mathematical supplement (volume 2, equation 1.19) did not faithfully translate his verbal theory of the capital account (volume 1, page 103), which recognised that a change in international interest rate differentials caused a once-and-for-all shift of existing portfolio stocks, as well as changing the proportions in which new additions to portfolio stocks are allocated between domestic and foreign assets."

As already mentioned, the monetary approach, presented in the next section, takes account of capital flows and includes stock adjustment effects.

V. The Monetary Approach

The monetary approach is a subset of the more general asset market approach. The latter argues that capital markets adjust to shocks much more quickly than goods markets and as a result, capital markets play a greater role in determining the BOP or the exchange rate in the short run. The presentation here of monetary approach (instead of the asset market approach) as the third major approach is defended on two grounds. First, it is agruably the most simple form the asset market approach can take, and as such represents the basic model from which extensions can be made (among them, the inclusion of more assets, resulting in more general asset market models). Second, it is the version of the asset market approach that has dominated the literature. The multiple asset model that might be representative of the real world is generally reduced to the monetary model, in which money is the only asset overtly dealt with, by one of two methods: the small country assumption is invoked, which fixes home country interest rates with respect to foreign rates which are assumed given, or; all domestic assets besides money are aggregated to form a second, interest bearing asset (or, more simply, the domestic economy is assumed to have only two assets, money and bonds) at which point Walras Law is invoked* to eliminate bond markets from the analysis. In the most extreme forms of the monetary approach (see Dornbusch (73) and Niehans (77)) money is assumed to be the only asset and so no interest rates exist, but this form of the approach is not as common or representative of the literature as are the forms that include interest rates.

*The difficult issue of applicability of Walras' Law and its implications are discussed in Kuska (78), Tsiang (77), and Hahn (77).

In what follows, I attempt to lay down what seems to have emerged in the literature as the critical components of the monetary approach to the BOP or exchange rate analysis. In searching for these components, I will cite writings on the topic by several authors and then try to sum up on the basis of those writings.

Harry Johnson (77, JIE, p.251), who must be considered to have been one of the core writers on the approach, wrote:

> "The central propositions of the monetary approach are, first, that the balance of payments is a monetary phenomenon and requires analysis with the tools of monetary theory and not barter or "real" trade theory; second, that money is a stock, whereas real theory traditionally deals with flows; and third, that the money stock can be changed in two alternative ways, through domestic credit creation or destruction and through international reserve flows, the policy choice being important for balance-of-payments analysis."

Johnson's first proposition is sometimes stated differently: in the monetary approach the exchange rate is viewed as the relative price of two national monies and not as the relative price of two national outputs, as it would be viewed in either the elasticities or absorption approaches. This idea is implicit in all writings on the monetary approach. The second point, emphasising that money is a stock, is reminiscent of Hume's price-specie flow analysis -- indeed, Johnson and many others (among them Fausten (79) and Mayer (80) have dealt with this topic exclusively) have acknowledged that the origins of the monetary approach are in the writings of Hume. Some make this point in support of the monetary approach as having historical origins, while others use the point to indicate that the monetary approach brings nothing new to BOP or exchange rate analysis. Johnson's third proposition is represented by the equation:

$$M_S = DC + IR.$$

A country's money supply is made up of a domestic credit component, DC, and an international reserve component, IR.

In another publication, Johnson (77 EIF) again cites two of these three components as being critical, writing (p.11):

> "that domestic money can either be created or destroyed by domestic monetary policy operating on the volume of domestic credit extended by the banking system or be imported or exported by running a surplus or deficit on accounts of the balance of payments other than the money account."

And, secondly (p.11), "that international money flows are a consequence of stock disquilibria--differences between desired and actual stocks of international money--and as such are inherently transitory and self-correcting."

But in an essay in The Monetary Approach to the Balance-of-Payments, which he edited with Jacob Frenkel, Johnson mentions three new crucial differences between the Keynesian (absorption) and monetary approaches--differences which he says form "the point of departure of the new 'monetary' approach to balance of payments theory" from Keynesian BOP theory.

Relative to the first of these differences, Johnson writes (p.152):

> "The new (monetary--parenthesis added) approach assumes--in some cases asserts--that these monetary inflows and outflows associated with (BOP--parenthesis added) surpluses or deficits are not sterilized--or cannot be, within a period relevant to policy analysis--but instead influence the domestic money supply. And, since the demand for money is a demand for a stock and not a flow, variation of the supply of money relative to the demand for it associated with deficit or surplus must work towards an equilibrium between money demand and money supply with a corresponding equilibration of the balance of payments. Deficits

> and surpluses represent phases of stock adjustment in the money market and not equilibrium flows, and should not be treated with an analytical framework that treats them as equilibrium phenomena."

There are, of course, two points made in this argument: 1) the non-sterilisation assumption--that authorities do not offset the effects of the BOP on the domestic money supply, and, 2) the "money is a stock" argument already encountered.

Secondly, Johnson points out (p.153) "that the 'monetary' models almost invariably assume--in contrast to the emphasis of the standard model on the influence of relative prices on trade flows--that a country's price level is pegged to the world price level and must move rigidly in line with it." This simply states that purchasing power parity is assumed to hold--though it is unclear whether Johnson is referring to the absolute or relative version of PPP. Most monetary models seem to use the absolute version as a simplification.

Finally, Johnson notes (p.155) that, "Whereas the Keynesian model assumes that employment and output are variable at (relatively) constant prices and wages, the monetary models assume that output and employment tend to full employment levels, with reactions to changes taking the form of price and wage adjustments."

In another essay in <u>The Monetary Approach to the Balance of Payments</u>, Michael Mussa lays down what he says (p.189) are "Three basic features of the monetary approach." The first of these (p.189) is that "the balance of payments is an essentially (but not exclusively) monetary phenomenon." We have already seen this idea in the writings of Harry Johnson. Secondly, Mussa writes (p.190) that the monetary approach uses "the money supply process and, particularly, the demand for money function as the central theoretical relationships around which to organize thought concerning the balance of payments." He says (p.190) that "the basic rationale for this principle of organization is that we are interested in the behaviour of the money account for which the demand for money and the supply of money should be of prime importance." This second point follows directly from the first.

Finally, Mussa puts forth (p.193) "the third basic feature of the monetary approach: a concentration on the longer run consequences of policy and parametric changes for the behaviour of the balance of payments." This concentration on the long run is a result of the fact that, (p.193) "The empirical evidence which justifies the assumption of a stable money supply process and a stable money demand function applies to periods of a year or more, rather than to periods of a month or a quarter." Thus this concentration is not a matter of choice, but a restriction of the model.

In fact, there seems to be some confusion about the time frame over which the monetary approach is applicable. As mentioned at the beginning of this section, it is often argued that asset markets are more efficient, and so clear much more rapidly than goods market. As such, one might expect that as a special case of the asset market approach, the monetary approach would be relevant in the short run.

Marina v. N. Whitman (75, p.497) points to a discrepancy in time horizon in an earlier Dornbusch model, which she takes as representative of the monetary approach, saying, "that it combines long-run full equilibrium assumptions on the demand side with the essentially short-run assumptions of the steady state on the output side."

Whitman also lists (p.494) the elements she believes are critical to the monetary approach--though she makes a distinction between the basic monetary approach and the more extreme "global monetarist approach". She says that the latter assumes "that, as a first approximation, the world consists, not of separable national economies, but of a single, integrated, closed economy." She lists five critical components of global monetarism, the first three of which she says are critical components of the monetary approach:

1) the non-sterilization assumption;
2) the assumption that the relationship between money supply and money demand plays a key role;
3) the assumption (p.500) "that the demand for money is fundamentally a stock demand characteristic of asset markets rather than a flow demand appropriate to output (commodity) markets";
4) the neutrality of money assumption;
5) the assumption that absolute PPP holds.

Although Whitman makes this distinction between the monetary and global monetarist approaches, it seems, on the basis of the writers already quoted, that other writers would include all of the characteristics of Whitman's global monetarism in their description of the monetary approach. We have seen the assumption that PPP holds in the writing of Johnson, and the neutrality condition, though perhaps not stated, is implied in most of the work on the monetary approach.

Although there are many more writers in this area, I have at this point named most of the critical components usually attributed to the monetary approach. This perhaps discursive presentation of the characteristics of the monetary approach has been used to demonstrate the difficulty one has in identifying what is meant by the monetary approach to the balance of payments or exchange rate determination. Indeed, the presentation would probably seem more discursive the more authors that were cited.

At this point, however, it is useful to sum up, and list the qualities that are generally attributed to, and will here be referred to as making up the monetary approach. Sources are listed, in parenthesis, some already cited, some not, in which the importance of the idea under consideration is discussed.

1) The BOP is a monetary phenomenon and as a result, the relationship between money supply and money demand is critical in determining the BOP or the exchange rate [Frenkel & Johnson (76, p.42), Mussa (76, MABOP, p.189-190), Johnson (in Allen and Kenen, 79, p.14), Zis (83, p.7), Mussa (76, SJE, p.230), Whitman (75, p.500)] .
2) The demand for money is a stock demand [(Johnson (77, EIF, p.11), Johnson (76, AER, p.449), Mussa (76, SJE, p.230), Dornbusch (73, p.872), Whitman (76, BP, p.500)] .
3) The domestic stock or supply of money is made up of domestic credit and international reserves[(Johnson (77, EIF, p.11), Johnson (in Allen and Kenen, 79, p.14), Branson (83, p.43), Salop (74, p.25), Whitman (75, p.496)] .
4) Authorities do not offset or sterilize the effect on domestic money supply of international payments imbalances [(Johnson (76, MABOP, p.152), Dornbusch (73, p.873) Johnson (76, AER, p.449), Whitman (75, p.499)] .
5) Purchasing power parity (in most cases the absolute version) holds [(Johnson (76, MABOP, p.153), Branson (83, p.41), Dornbusch (73, p.872), Dornbusch (80, BP, p.145), MacKinnon (81, p.546)] .

6) Output is at the full employment level[(Johnson (76, MABOP, p.155), Dornbusch (73, p.871), Branson (83, p.42), Whitman (76, p.496)].

In addition to these central concepts or assumptions, there are some other common threads running through the literature on the monetary approach to the BOP. As already stated, the small country assumption and Walras Law are often included in monetary approach models. As has also been mentioned, there is some confusion as to the time frame over which the approach is relevant, but in floating exchange rate models it is commonly assumed that capital markets are more efficient than goods markets and as a result, that they react nearly instantaneously to shocks--in short, capital is assumed to be perfectly mobile. If assets of different countries are assumed to be perfect substitutes, as is often the case, perfect capital mobility implies the maintainence of uncovered interest parity: the domestic interest rate, i, is at all times equal to the foreign interest rate, i_f, less the expected amount of appreciation of the home currency, $E(\hat{S})$ (where the exchange rate, S, is in terms of foreign/domestic currency units and so an appreciation of the home currency is seen as an increase in S, and the circumflex, ^, represents the proportional rate of change in a variable):

$$i = i_f - E(\hat{S}).$$

Thus exchange rate expectations are brought into the analysis. Various expectations formation equations will be discussed as part of section VI.

Finally, it is perhaps useful at this point to cite an excerpt from Branson's comment (75, p.538) on Whitman's (75) paper in which he graphically relates the elasticities, absorption, and monetary approaches:

"Beginning with the standard IS-LM model of income determination, I want to introduce, in the interest rate-income space, a third line that is the locus of points where the balance of payments is zero. Call this the BP line; it is positively sloped (because higher domestic interest rates will induce capital inflows which must be offset by a current account deficit resulting from higher income if BOP is to remain at zero--parenthesis added). If the IS-LM equilibrium intersection is above the BP line, the economy is experiencing a balance of payments surplus; below the BP line, a deficit (all this assuming fixed exchange rates). A change in the exchange rate shifts both the BP and IS curves in this picture, and the elasticity story is about the direction and extent of these shifts, while the absorption story is about the economy's reaction to them. The monetary approach simply adds to the story the observation that if the effects of a nonzero balance of payments on the money supply are not sterilized, the momentary IS-LM equilibrium point cannot be a full equilibrium since the money supply is changing."

VI. Components and Extensions of Balance of Payments or Exchange Rate Modelling

In this section I will consider various characteristics, some of which may or may not be included, and other which will be included in one form or another in modelling exchange rates or the BOP. As was already mentioned, by manipulating these components, we may start with one of the basic models, say the absorption approach model, and gradually evolve it into one of the other basic models, studying the effects of each of the steps in the evolution. In fact, as indicated in an earlier quote (footnoted) of Harry Johnson, much work has been devoted towards attempting syntheses of two or more of the basic approaches [see Salop (74), Frenkel, Gylfason and Helliwell (80), McCallum and Vines (81), and Gylfason and Helliwell (83)] . In addition to moving back and forth between the basic models, manipulation of the following components may also result in models that have characteristics unlike any of the three basic models and as such are truly extentions.

It would, of course, be impracticable to discuss every combination of these components ever studied. Instead, each aspect or extension of modelling is described in the various forms it can take, the impact of using each of those forms on modelling is briefly discussed, and some examples from the literature of models using the various forms of that component are cited.

A. Expectation Formation Equations

In this subsection we will examine some of the expectation formation equations that are most commonly used in the literature. While the following are representative, other expectation formation assumptions can also be found in the literature (indeed, the problem of expectation formation has become a focal point, not only in exchange rate modelling, but in economic modelling in general). Giddy and Dufey (75), for instance, have used various statistical techniques, ranging from the simple martingale or random walk hypothesis to time series analysis and time series with exponential smoothing, in attempts to model expectations. Meanwhile Long (76) has proposed a fairly sophisticated learning function which he postulates market participants use in forming exchange rate expectations. The majority of the exchange rate modelling literature, however, uses some variant of one of the following expectation formation methods.

1) Static Expectations

With the exception of the hypothesis that agents always expect the value of the variable in question (the exchange rate in our case) to be equal to some constant, static expectations probably represent the most simple expectation formation assumption available. If ${}_t^eS_{t+1}$ is the expected value of the exchange rate at time t+1 as estimated at time t, and S_t is the value of the exchange rate at time t, then static expectations are represented by the equation:

$$ {}_t^eS_{t+1} = S_t. $$

Economic agents expect the exchange rate to stay where it is. With an error term added in, this becomes the random walk or martingale hypothesis.

Branson (79), Dornbusch and Fischer (80), Enders (77), Kouri (76), and Masson (81) all use the assumption that expectations are static.

2) Regressive Expectations

Under regressive expectations it is assumed that there exists some long run steady state value of the exchange rate which can be calculated at present, and to which the exchange rate is constantly moving via period by period adjustments. In this case the expected change in the value of the exchange rate from one period to the next is equal to some portion, Ψ, of the difference between the long run and present values of the exchange rates, $\bar{S}$ and S_t respectively:

$$ {}_{t}^{e}S_{t+1} - S_t = \Psi(\bar{S} - S_t). $$

Ψ is usually assumed to be between zero and one, and represents the anticipated speed of adjustment of the exchange rate to its long run steady state level.

Regressive expectations have been used in Dornbusch (76), Girton and Henderson (74), Masson (81), and Niehans (77). Frenkel (79) uses a regressive expectations equation with an added term which attempts to account for the effect on expectations of divergent inflation rates across countries.

3) Adaptive Expectations

The adaptive expectations hypothesis which was introduced by Cagan (56) is based on the idea that economic agents observe any differences between their past estimates of the exchange rate and the actual value to which those estimates corresponded and that agents then try to adjust their present expectations to avoid those past errors. The most common form this adaptiveness is assumed to take is represented by the equation:

$$ {}_{t}^{e}S_{t+1} - {}_{t-1}^{e}S_t = \Phi(S_t - {}_{t-1}^{e}S_t), $$

where the degree of adaptiveness (or the extent to which agents adjust to avoid past errors), Φ, is assumed to be between zero and one.

Discussion of, or models that include, adaptive expectations are found in Beenstock, Budd, and Warburton (81), Begg (82), Burmeister and Turnovsky (77), Dornbusch (76 SJE), Khan (77), and Kouri (76).

4) Extrapolative Expectations

Under extrapolative expectations it is assumed that the exchange rate will continue to appreciate or depreciate at the same rate it has in the past. The most simple form this hypothesis can take is represented by the equation:

$${}_{t}^{e}S_{t+1} - S_t = S_t - S_{t-1} .$$

This hypothesis will perform well when the exchange rate is changing at a constant rate, but it will always overshoot peaks and troughs in the exchange rate.

Extrapolative expectations are discussed and used in modelling in Artus (76), and Haas and Alexander (79).

These four expectations formation assumptions can be better compared and contrasted when they are rearranged into the parallel forms:

Static Expectations	${}_{t}^{e}S_{t+1} = S_t;$
Regressive Expectations	${}_{t}^{e}S_{t+1} = (1-\Psi)S_t + \Psi\bar{S};$
Adaptive Expectations	${}_{t}^{e}S_{t+1} = \Phi S_t + (1-\Phi)\,{}_{t-1}^{e}S_t;$
Extrapolative Expectations	${}_{t}^{e}S_{t+1} = S_t + (S_t - S_{t-1}).$

It is clear that the current value of the exchange rate plays an important role in each of these expectation mechanisms. Indeed, the last three mechanisms have the static expectations equation as a special case, and each can be seen as an extension of the static expectations mechanism.

The static expectations hypothesis will perform well only when the exchange rate is constant over time--but this is the special case under which the three other expectation formation equations reduce to the static mechanism. As such, static expectations offers little advantage over the other three mechanisms except simplicity.

The regressive expectations hypothesis states that the exchange rate is expected to move asymptotically from its current value to its steady state value and therefore will perform best when such a path is followed. This mechanism presents the difficulty that the steady state value of the exchange rate must be calculated, but contains the benefit that shocks to the system that alter the long run direction of the exchange rate are incorporated immediately--which is not the case with the other mechanisms. This hypothesis reduces to the static expectations case when the present value of the exchange rate is equal to its steady state value, or when the rate of adjustment of the exchange rate to its long run value (Ψ) is equal to zero.

Under adaptive expectations, expectations are assumed to adjust from their previously held value toward the current value of the exchange rate so that past expectational errors will be partially accommodated. There is really no time path of the exchange rate to which this expectation formation mechanism is perfectly suited--it is a sort of compromise mechanism aimed at minimising the error in expectations over time. It reduces to the static mechanism when past expectations prove to be correct, and when past expectational errors are completely adjusted for (when $\Phi = 1$).

Finally, under the extrapolative mechanism, the exchange rate is expected to move from its current value in the direction, and to the extent, it has moved in the past--that is, it is believed that any momentum in exchange rate movements will be preserved. This equation reduces to the static equation only when the exchange rate is indeed static over time.

Systematic forecasting errors can be displayed by any of these mechanisms. If the exchange rate is appreciating or depreciating along a continuous path, the inclusion of the current value of the exchange rate in each of these equations injects the possibility of systematic error into the forecast. The last three expectation formation mechanisms each include another source of systematic forecasting errors. With regressive expectations, movement of the exchange rate away from the long run rate, or even towards the long run exchange rate at a rate different from that implied by Ψ will result in systematic errors. Under adaptive expectations, a sustained change in the direction of the exchange rate in any direction (appreciation, depreciation, or stability) will result in systematic errors since the forecasting error will be whittled down only partially (as indicated by Φ) each period. Using extrapolative expectations systematic errors will result whenever the rate of change of the exchange rate is changing--that is, whenever the rate of appreciation or depreciation of the exchange rate is accelerating or decelerating.

5) Rational Expectations

The first four expectation formation mechanisms we have seen are all backward looking mechanisms--they are all calculated using data from the past--and as such are unable to take into consideration anticipated changes in the exchange rate or any of the variables on which the exchange rate depends.

Rational expectations theory attempts to correct this deficiency by assuming that agents use all available information (including official policy announcements, widely held expectations of the occurence of some event, etc.) to arrive at forecasts that do not include systematic errors. Muth (61) is usually given credit for initially formulating the rational expectations hypothesis, though, as Begg (82) has pointed out, Muth was really just formalising the earlier work of Modigliani and Grunberg (54). Other articles considered critical in the development of rational expectations theory are Lucas (72) and Sargent and Wallace (73) and (75).

This hypothesis generally manifests itself in the literature in one of two forms: 1) the non-expectations part of the model is assumed to be a good approximation to the true model and agents are assumed to be aware of the model and use it in formulating their expectations; and, 2) the fact that forecasts are assumed not to have systematic errors, which means that forecast errors are randomly distributed around a mean of zero, is extended into the idea of certainty equivalence. Under the latter, agents' expectations of the value of a variable at time t+1 are equal to the actual value of that variable at time t+1 plus a white noise error term,

$$ {}_t^eS_{t+1} = S_{t+1} + e. $$

This second manifestation of the rational expectations hypothesis has helped to repopularize the perfect foresight hypothesis. Perfect foresight is represented by the equation above without the error term, e, and can be arrived at by combining this second manifestation of the rational expectations hypothesis with the assumption that economic agents possess perfect information.

Applications and implications of the rational expectations theory are discussed in greater detail in a later chapter.

Discussion or application of some form of the rational expectations approach can be found in Begg (82), Calvo and Rodriguez (77), Dooley and Isard (81), and Hacche and Townend (81). Models using the first manifestation of the rational expectations hypothesis are found in Barro (78), Beenstock, Budd, and Warburton (81), and Dornbusch (82). Models using the second manifestation of the hypothesis can be found in Buiter and Miller (81), Dornbusch and Fischer (80), Ethier (77), Gray and Turnovsky (79), and Kouri (76).

6) Forward Rate Based Expectations.

Some have argued that if foreign exchange markets are efficient, then the forward rate--the difference between the exchange rates at which someone will buy (or sell) a given currency today and promise to sell (or buy) that same currency back at some future date--should be a good measure of the market's expectations as to the direction and magnitude of changes in future values of the exchange rate. Arbitrage assures that the forward rate, F, is closely related to the interest rate differential between the two countries whose exchange rate is under study:

$$F/S = i_f - i$$

where S is the spot rate (previously referred to simply as the exchange rate) and i and i_f are the domestic and foreign interest rates, respectively. If F repesents, for instance, the 3 month forward rate, then the interest rates will be 3 month rates. Owing to this constraint, it is not clear that the forward rate is a good predictor of future values of the spot rate--or even that it provides forecasts without systematic error.

Discussion and/or application of the forward rate as a predictor of future values of the spot rate are to be found in Baillie, Lippens, and McMahon (83), Frenkel (77) and (81), and Giddy and Dufey (75).

Before leaving expectations, it seems relevant to point out that in some models exchange rate expectations are assumed to be simple functions of expected differentials in inflation or interest rates between the two countries in question. In any case, these expected differentials are always arguably relevant in exchange rate expectation formation. For this reason, some references on inflation and interest rate expectation modelling are included. Makin (82), Fama (76), and Elliott (77), study the formation of interest rate expectations and Cukierman (77), Gramlich (83), and Tullio (81, IMFSP) look into inflation expectation formation.

B. Anticipated and Unanticipated Shocks to the System

As we have seen, the rational expectations hypothesis states that economic agents do not make systematic errors in their forecasts of economic variables (the exchange rate in our case). As such, one might expect that discussion of the effects of anticipated and unanticipated shocks to the system, of announcement and preannouncement effects, etc., would figure heavily in the rational expectations literature. In fact, discrete inclusion of these items is treated more as an extension to the rational expectations approach.

Using this extension, the exchange rate is modelled as being determined by a systematic, anticipated, or deterministic part (which is the model on the basis of which agents might be assumed to form their expectations of the future rate of exchange), and an unsystematic, unanticipated, or stochastic part (which may simply be a white noise error term, but commonly includes "news" that has an effect on the exchange rate such as announcement by authorities of policy changes, oil embargoes, military coups and the like). This extension is useful in studying how unanticipated news is assimilated into future expectations (into the systematic part), especially in cases where the news is preannouncement of a policy change, say in the monetary growth target, which can give expectations more forward looking character. Models with anticipated and unanticipated components may also be used to compare the consequences of announcement and preannouncement of policy changes.

Begg (82, p. 231) Dornbusch (80 BP), Ethier (79), Frenkel (81 JPE), Wilson (79), Barro (78) and Kimbrough (83) discuss or present models that discretely include anticipated and unanticipated effects. Blejer and Mathieson (81), Beenstock, Budd, and Warburton (81), and Buiter and Miller (81) all use models with systematic and unsystematic parts to compare the effects of announcement and preannouncement of policy changes.

C. Risk

Closely related to expectations is the idea of uncertainty related to those expectations, and the implied risk that results from that uncertainty. In fact, as Eaton and Turnovsky (83, AER, p.183) have pointed out, there are usually considered to be two types of risk that must be considered when dealing in foreign exchange: "One is exchange risk: the values of the two bonds are defined in terms of different currencies and the exchange rate at the date of maturation is uncertain. The second is default risk: investors may perceive that foreign bonds are more subject to the risk of default than are domestic bonds."

Exchange risk can be analysed in a number of different ways. As implied above, exchange risk may be thought of as the probability that the future value of the exchange rate will be different from the investor's expected value in the direction that results in a loss for the investor. Levy and Sarnat (78) have analysed exchange risk in terms of the variance of the exchange rate in question, while Ladenson (74) defined more of a one-tailed criterion, specifying exchange risk as the probability that the currency being held will devaluate.

Default risk relating to foreign exchange is often dealt with under the more general heading of Political Risk, which Aliber (73, JPE, p.1453) has defined as "the probability that the authority of the state will be interposed between investors in one country and investment opportunities in other countries." This includes default risk and the risk of capital flow restrictions will be imposed.

Wihlborg (82, p.58) has discussed ways in which both exchange and political risks can effect exchange rate determination:

> "First, risk aversion and different risk characteristics of assets denominated in different currencies provide the foundation for the portfolio formulation of demand functions for different assets. Second, changes in the levels of risks would affect the elasticities of substitution among different assets and therefore the effectiveness of monetary policy. Third, changes in the levels of risks on alternative assets could have a direct impact on relative rates of return."

The interdependence of economies and degree of substitutability of currencies are components of modelling that will be considered in a later subsection of section VI. Wihlborg's second point bears an important implication that must be considered when picking among the various model components in this section to begin making a model: some of these components are mutually exclusive, or at least impact the degrees of freedom of the model and thus limit the choices for other components to be included in the model. Wihlborg's third point identifies the interest rate premium that is usually identified with currencies associated with above average exchange or political risk.

Models including exchange and/or political risk can be found in Adler and Dumas (76), Blejer & Mathieson (81) Dooley and Isard (80), Dooley (82), and Eaton and Turnovsky (83). Empirical work on risk and risk premiums can be found in Aliber (75), Blejer (82), Levy and Sarnat (78), and Wihlborg (82).

D. The Degree to which Floating Exchange Rates are Managed

Although it is common to find references in the literature to models as being "fixed rate" or "floating rate," much attention has been given to the fact that exchange rate regimes are rarely, if ever, truly represented by one of these two extremes. In a fixed rate regime exchange rates are allowed to float within a defined range, and when rates are floating, some degree of exchange rate manipulation is usually going on. Indeed, Batten (82), Melitz and Sterdyniak (79), and Williamson (76) have all presented evidence that official reserve use has been considerable during the recent float. Here we use intervention to mean buying and selling of currencies in the foreign exchange markets by governmental authorities, and not implementation of trade or capital flows controls or other BOP manipulating devices that will be discussed in the next subsection.

Many models have been formulated that avoid the fixed rate constraint, $\Delta S = 0$, and the floating rate constraint, BOP=0, and thereby result in hybrid models that in some cases can be shown to have the two extreme cases (fixed and floating rates) as special cases. Konig and Gaab (82), Boyer (78), Genberg (81), Girton and

Henderson (74), Eaton & Turnovsky (84), Artus (76) and Rodriguez(81) have used such models to study the effects of intervention on a "floating" exchange rate and on the economics involved. Helpman (81) observes the economic consequences of the evolution from a floating regime to a one-sided peg (in which the authorities of one of the countries whose exchange rate is involved intervene to fix the exchange rate) to a two-sided peg (in which the authorities of both countries intervene to fix the exchange rate). Blejer and Leiderman (81) model a crawling peg regime--in which the exchange rate is periodically changed, often on a predetermined schedule, but is at all other times fixed (a policy often used by countries experiencing hyperinflation)--and then apply that model to Brazilian data. Brown (77), Dornbusch (76), and Nowak (84) have presented models with dual exchange rate regimes--in which some international transactions (usually trade related) take place via a floating exchange rate, while other international transactions (usually capital flow related--dual regimes are often proposed as a remedy for excessive exchange rate speculation) take place at fixed exchange rates.

Many studies, including some of those above, have addressed the relationship between the exchange rate regime and the degree of economic independence attained by the countries involved. Before the present float, proponents of floating rates [Friedman (53) and Johnson (70) among others] argued that floating rates would allow authorities greater autonomy in dealing with domestic economy issues since exchange rates would adjust to protect all economics from external shocks. Black (82), Chan (79), Daniel (81), Girton and Roper (77), Hamada and Sakurai (78), Heinson and Policano (82) and Weber (81) all study the relationship between the exchange rate regime and the interdependence of economies. As we saw in subsection VI.C., the substitutability of countries assets will impact the degrees of policy independence enjoyed by those countries. In addition, Dornbusch, Branson, Swoboda and Arriazu (all in IMFSP, March, 1983) all presented papers at a special IMF conference on the subject. The conclusions of these authors vary, but the general consensus is that floating rates do not afford the degree of independence once believed.

E. Openness of the Economy

The independence of a country's economy relative to the world economy also depends on the extent to which the country is open to, and takes part in, the world economy. Frenkel and Mussa (81) discuss various linkages that exist between international economies, while MacKinnon (81) discusses differences in modelling insular and open economies. I will break this issue down into two parts, the openness of the current account, and that of the capital account.

1) Current Account

The effects of trade controls on the welfare of the countries involved have probably been debated since such controls were first used. Discussion of such controls is found in the writings of Adam Smith (1776) and David Ricardo (1817). There is probably no country on earth that uses no trade controls. To the extent such controls alter trade flows, inclusion of them in exchange rate modelling is arguably relevant--especially in cases that those controls are frequently altered and so might inject structural breaks into estimates of the model. Caves and Jones (81, p. 199-273) and Meier (80, p. 84-124) discuss various forms trade controls most commonly take. Generally speaking, controls fall into one of two categories: 1) Price changing controls such as tariffs on imports or export subsidies; and, 2) quantity controls such as import quotas. Dornbusch (80, OEM, pp. 62-69), Khan and Knight (81), Khan and Zahler (83), and Mussa (76) all discuss and/or model the effects of trade controls on the exchange rate and on welfare levels of economies. Controls that make exports more attractive or more available to foreigners tend to improve the BOP (under fixed rates) or pressure the home currency towards appreciation, as do controls that make imports more expensive or less available to domestics.

2) Capital Account

Recent work has placed considerable emphasis on the effects of capital flows on the exchange rate--especially in the short run. In general, the more highly integrated international capital markets are, the larger will be the capital flows induced by a given change in the expected relative yields of countries' assets.

Penati and Dooley (84) have studied the correlation between 19 countries' savings and the levels of investment in those countries as well as other measures of capital integration, and have concluded that international capital markets are not as highly integrated as is commonly believed. Brillembourg and Schadler (79), Calvo and Rodriguez (77), Chung (83), and McKinnon (82) have all studied the substitutability of major currencies in the world capital markets, giving evidence that some currencies are substitutes, others are complements, and others are not significantly correlated. Related to substitutability is the idea of vehicle currencies--the existence of a few currencies that are internationally accepted as media of exchange, therefore increasing the trade in, and demand for, those currencies relative to other currencies. Vehicle currencies are discussed in Krugman (80), and Swoboda (69).

Like trade controls discussed above, capital controls used by authorities generally either take the form of quantity controls like restrictions on the volume of capital outflows, or the form of price changing controls like taxes on interest earned in a foreign country. Adler and Dumas (76), Brown (77), Buiter and

Miller (81), Dooley and Isard (80), Dornbusch (80, OEM), Dornbusch (83), Helpman and Razin (82), Nowak (84), and Ruffin (79) all discuss and/or model the effects of capital account controls on the exchange rate and on the economies involved.

F. Large/Small Country Assumptions

The size of the country (or countries) under study relative to the rest of the world will determine the extent to which that country's (or those countries') policies and actions will affect and will be affected by the rest of the world. In the goods market, the distinction is parallel to that between the monopoly or oligopoly firm and the firm in a perfectly competitive environment; the large country is assumed to face downward sloping demand curves while the small country is assumed to be able to trade any amount of tradable goods at a fixed world price. The size of the country impacts more than just the price at which it can trade, however. The price of internationally traded assets, the interest rate, can be assumed to be determined largely at home (the large country assumption) or by the given world rate (the small country assumption). The domestic economy can be assumed to serve as the "engine" of the world economy, stimulating income growth in other countries through its demand for their exports (the large country assumption), or it can be assumed to have no effect on the income levels of other countries or even dependent on those countries' income levels (the small country assumption). The assumption that a country's currency serves as a vehicle currency, with its implications for monetary policy, is often considered to be a facet of the large country assumption. A country may be modelled as small in some areas and large in others. For instance, South Africa, if modelled, might be considered large in terms of world gold and diamond markets, but small in many other respects.

Discussion of the manifestations and implications of the various assumptions that can be made relative to a country's size, along with models that explicitly state the size assumptions used are found in Barro (78), Blejer and Leiderman (81), Branson (75), Branson (83), Calvo and Rodriguez (77), Casas (75), Enders (77), Dornbusch (74), Frenkel and Johnson (76, pp. 26-7), Humphrey (82, p.121), Kouri (76), Masson (81), Niehans (77), Obstfeld (81) and (82), Pearce (61), Ruffin (79), and Steinherr (81) among others.

G. The Number of Countries Included in the Model

The existence of at least two countries is implied in the modelling of an exchange rate. Yet the extent to which variables generated in foreign economies are appropriate for inclusion in a given model depends on the volume and nature of the home country's trade in goods and capital.

Chen (73) has pointed out that a one-country model, which might be used if the home country were assumed to be a large country, would not be appropriately applied to an open small country, whose price level, interest rates, and income levels may be largely determined abroad.

The most common number of countries to be used in exchange rate modelling is two, the home country, and an aggregation of all of the home country's trading partners called the "foreign country." For examples of two country models see Adler and Dumas (76), Aschauer and Greenwood (83), Dornbusch (73), Dornbusch, Fischer and Samuelson (80), Enders (77), Heinson and Policano (82), and Helpman (77). Hacche and Townend (81), Klock, Pigott, and Willett (75), Artus and Rhomberg (73), and Rhomberg (76), all discuss the fact that when the foreign country represents an aggregation of trading partners (instead of one trading partner, trade with whom dominates the international transactions of the home country) it should be some effective exchange rate (a weighted average of the exchange rates of those trading partners) that is modelled.

Finally, multi-country models (in which more than two countries are discretely modelled) represent an improvement if using a two country model involves aggregation problems--if the trading partners all produce different goods for which the home country has different elasticities of demand, for instance. Bhandari (81) and Golub (83) present bilateral exchange rate models in which three countries are included.

H. The Number of Goods Included in the Model

A variety of assumptions can be made about the number of goods that are produced and consumed in the world and (if that number is greater than one) about the characteristics that distinguish one good from another.

The most simple assumption is that only one good, or equivalently, one homogeneous basket of goods, is produced and consumed by all countries in the world. If this good is not tradable, then the countries of the world would have closed commodity markets, but it is generally assumed that if only one good exists it is tradable. In this case money, or some other store of value must exist so that intertemporal trade can occur--otherwise, there would be no incentive to trade at all. Purchasing power parity, or the law of one price, is usually assumed to hold as a result of cross country commodity price arbitraging on the good. Aizenman (84), Dornbusch (73), Obstfeld (81), and Ruffin (79) formulate models with only one good, that good being tradable.

Expansion to the two commodity setting usually takes place in one of two ways: either a domestically produced non-traded good is included, or the domestic and foreign produced traded goods are assumed to be differentiated. Much attention has been focussed on the two commodity world with traded and non-traded goods. Swoboda (73) has pointed out that to the extent that the domestic economy is dominated by production and consumption of non-traded goods, then the commodity sector is nearly closed. But when traded and non-traded goods both make up significant parts of the goods produced and consumed by domestic residents, the relative price of these two goods can be critical in determining the level of absorption by domestics, the amount of the two goods that are produced and therefore the way factors of production are employed. Commenting on the efficiency of the elasticities approach, Pearce (61, p.2) wrote: "Indeed, it may well be that the currency depreciation succeeds in practice more because it decreases the price of non-traded goods relatively than because it affects the real terms of trade."

Discussion of the tradable/non-tradable goods distinction, and two good models using this distiction are found in Barrett (81), Blejer (77), Blejer and Leiderman (81), Bruno (78), Calvo and Rodriguez (77), Dornbusch (76), Flanders and Helpman (78), Frenkel and Johnson (76, pp. 27-8), Helpman (77), Minford (81), and Obstfeld (82).

When the second good results from assumed differentiation of domestic and foreign goods, relative pricing of those goods becomes more complicated; arbitrage will not ensure parity in pricing of those goods, but should instead ensure parity of their relative price across countries. Dornbush and Fischer (80), Enders (77), and Frenkel and Rodriguez (82) present two good models in which each country produces a differentiated tradable good.

Bruno (76), Mathieson (73), Mussa (82), and Pearce (61) all develop three good models which combine the ideas of the two good settings discussed above: the three goods are a domestically produced non-tradable good, a domestically produced tradable good, and a foreign produced tradable good which is different from the domestically produced tradable good. Such models, especially when contrasted to one of the two good models, allows one to compare the effects of inclusion of the non-traded good and the differentiated foreign tradable good.

Finally, Dornbusch, Fischer and Samuelson (80) use a model of international trade with a continuum of goods to study factor price determination, and dispersal and employment of factors of production.

I. The Number of Assets Included in the Model

Many of the recent models assume that asset markets and their equilibria play a major role in determining the exchange rate, while other models assume that no assets are internationally traded and even that money is the only asset. Various assumptions about the number of assets that exist, the nature of those assets, and the consequences of those assumptions will be discussed in this subsection.

Barro (78), Calvo and Rodriguez (77), and Niehans (77) all develop models in which domestic and foreign monies are the only assets that exist and domestic residents are allowed to hold either currency. Although no interest rate differential incentive exists for holding one currency over another, expected exchange rate movements will result in a positive expected yield for holding one currency and a negative expected yield for holding the other. Dornbusch (73) and Helpman (81) restrict the two money model further by assuming that residents of each country can only hold their country's currency. In this formulation capital flows are ruled out and the money markets only affect the exchange rate via the goods market and trade in goods.

The most common portfolio balance type (which emphasize the affect of asset stock adjustment induced capital flows on the exchange rate or the BOP) models include domestic and foreign monies and domestic and/or foreign bonds, sometimes with restrictions on which assets can be held by domestic residents. Introduction of interest rates (as compared with the money only models described above) through inclusion of bonds complicates money and goods market equations as well as the equation for the expected relative yield of domestic and foreign assets. Beenstock, Budd and Warburton (81), Enders (77), Girton and Henderson (77), Kouri (76) and Mason (81) present models in which money and bonds exist.

Burmeister and Turnovsky (77), and Adler and Dumas (76) develop models with other assets in addition to money and bonds, studying how the possibility of still greater diversification affects portfolio choices, asset returns, capital flows, and the exchange rate.

J. The Demand for Money Function

There is an extensive literature dedicated to the demand for money function (its appropriate specification, its stability over time, etc.) which is separate from literature on how this function affects exchange rate or BOP modelling. The purpose of this sub-section is not an in depth discussion of this literature, but a brief overview of the major topics of concern and the observation that this literature is relevant to exchange rate modelling.

Basic references in this area are Keynes (36), Robertson (46), and Friedman (59). The most commonly used demand for money function, sometimes referred to as the Cambridge form, is:

$$M_d/P = L(Y,i).$$

The real demand for money, which is the nominal demand for money, M_d, divided by the price level, P, is a function of the real income level, Y, (which is assumed to be positively related to real money demand, since people with higher real incomes will demand more money for transactions, speculation, or whatever) and the nominal interest rate, i, (which is assumed to be negatively related to real money demand because the interest rate is the cost of holding money instead of interest bearing assets, and is also often assumed to be exponentially related since at low interest rates money demand may be more responsive to a given interest rate change). Even if this basic form is agreed upon, there are still many problems to face if it is to be applied, as pointed out in Khan (74), and Meyer and Neri (75). Theory does little to direct which nominal money supply measure should be used, which price level measure should be used, whether income or permanent income should be used, and which interest rate measure should be used. These matters will be discussed in more detail in the empirical chapters that follow. Khan also studies the stability of this money demand function over time, finding it fairly stable over the period 1901-65.

As Tsiang (77, p.321) observes, however, there is another basic money demand function that is often used:

> "Either nominal money balances are described as a function of real income, the interest rate and the price level (the Cambridge form discussed above--parenthesis added), or nominal money balances are treated as a function of the money value of total real wealth and the interest rate. Apparently, the choice of income or wealth as the chief argument of the demand function for money is treated as immaterial..."

This second, real wealth related money demand function emphasises the role of money as an asset in a portfolio (speculative demand for money) instead of money's role as a medium of exchange (transactions demand).

Frenkel's (77) hyperinflation model includes an inflation term in the money demand function, arguing that during hyperinflation, inflationary expectations dominate money demand.

K. Stocks and Flows

The distinction between stock and flow phenomena was discussed earlier in the context of the monetary model. But this distinction is important enough, and dealt with in the recent literature enough, to merit further study.

A useful starting point is a paper by Harrison (80) in which the author defines three basic ways in which the stock/flow distinction is commonly made in the literature. First, he says that trading plans, because they are executed at a point in time, are dimensionally stocks and not flows. Second, he cites discussion by Hicks which makes what Harrison calls (p.113) a behavioural distinction "that calls the activities of current period production and consumption 'flow activities' and the activity of asset holding a 'stock-activity.'" Finally Harrison (p.113) makes what he calls a heuristic distinction, citing Patinkin, who defined a "flow"

> "as a quantity whose magnitude is directly proportionate to h (the length of the market/planning period); similarly, the implicit definition of a "stock" is that of a quantity whose magnitude is independent of h."

Less technical discussion of the stock/flow distinction and its implications is found in Frenkel and Johnson (76, pp. 30-31) Grubel (76), Isard (78), Johnson (76), and Lindbeck (76). Basically, a stock demand for a good or asset is the result of the desire to hold reserves or hoards of that good or asset (though Harrison's first type of stock/flow distinction makes it clear that this definition is not used by all).

The flow demand for a good, on the other hand, results from the desire to consume that good and the flow demand for assets usually results from the need to use those assets to acquire goods for consumption (as in the transactions demand for money). Obviously flows of goods or assets can result from flow demand for those articles or from the changes in the stock demand for those articles which will result in stock adjustment induced flows. This point is made by Lindbeck (76, p.134):

> "A stock formulation reminds us that (some) flows can fruitfully be seen as adjustments to desired stocks, and that (those) flows become zero when desired stocks have been reached (if net wealth is constant). Thereby a stock formulation helps to clarify when a flow is temporary (stock adjustment induced) and permanent (when resulting from flow demand.)" - parenthesis added.

The extreme attention recently given to stock considerations in exchange rate and BOP modeling are in part due to the fact that, as mentioned earlier, the elasticities and absorption approaches, as well as the seminal work on the monetary approach by Mundell (60) and (62) and Fleming (62), dealt exclusively with flows, neglecting stocks and stock adjustments. Tsiang (75) and Cooper (76) discuss this shortcoming in the work of Mundell and Fleming. Among the faulty implications of a Mundell-Fleming type model is the idea that the volume of capital flows is a function of the interest rate differential between the countries in question. A model that includes stock considerations instead implies that capital flows are a function of the change in interest rate differential because it is the change in this differential that induces stock adjustments, which result in capital flows.

Models that include both stock and flow impacts on the exchange rate or BOP can be found in Branson (76), Driskill (81), Frankel and Rodriguez (75), Friedman (77), Golub (83), Niehans (77), and Tsiang (75).

L. Real Income

The most simplistic way real income can be treated in a model is to assume no growth and that real income is fixed, usually at the full employment level. This scenario, which is generally accompanied by the assumption that prices are flexible, implies that income is supply determined--prices adjust to keep demand in line with supply (the output supplied corresponding to the level at which all available factors of production are employed). The assumption that income is fixed is usually associated with a long run perspective, since over the long run prices are more likely going to be able to adjust enough to equate supply and demand and thereby keep income steady. Arndt (77), Dornbusch (73), and Dornbusch and Fischer (80) present models that use the fixed income assumption.

Flood (79) and Aschaner and Greenwood (83) develop other models in which income is supply determined but in this case, owing to the small country assumption, prices are largely determined by foreign phenomena. Thus output or income is not fixed, but fluctuates, depending on the price level.

Alternatively, it is often assumed that income is demand determined--that producers are willing to supply whatever volume of goods are demanded at a given point in time. This is the Keynesian perspective, generally associated with fixed or sticky prices, and therefore with the shorter run in which prices do not have time to adjust. Buiter and Miller (81), and Dornbusch (76 JPE), (80, OEM, pp.33-56), and (82) present models in which income is demand determined.

The above ways of modelling income can be used for describing how income at any point in time is related to the full employment income level, usually taken as fixed. It is possible, of course, that due to advancing technology and/or productivity, or growing population, or for other reasons, that the full employment level of real income is changing (presumably growing) over time. This growth can be modelled as constant, or cyclical, or in other ways, but in any case, it is the growth of the full employment income level that is being modelled, and the actual income level will usually be related to that full employment level in one of the ways already described. Kreinin and Officer (78) discuss growth in the context of exchange rate and the BOP and Ruffin (79) and Solow (56) develop international growth models.

M. Prices

As was alluded to in the last subsection, the most simple assumption that can be made about price determination is that prices are perfectly flexible, instantaneously adjusting to market clearing levels. In most models, price flexibility means that income will always be at the full employment level, but flexibility can impact the exchange rate or the BOP in a number of ways, depending on the specifics of the model. Branson (83), Dornbusch and Fischer (80), and Kouri (76) present models in which flexibility plays an important role.

For shorter term modelling, more realism may be obtained by assuming that prices are sticky and adjust to equilibrium levels only after or over some period of time. Probably the most famous of the recent papers to employ sticky prices in exchange rate modelling is Dornbusch (76 JPE) in which prices are assumed to move towards some pre-calculatable long run steady state level. This price stickiness results in the possibility of short run goods market disequilibrium which, coupled with the assumption that asset markets clear instantaineously, helps produce Dornbusch's famed overshooting hypothesis. Arndt (77) assumes sticky prices that make a once and for all adjustment to equilibrium when they finally move--arguably a less realistic scenario than Dornbusch's. Dreze (75) and Sweeney (77) present other models with sticky prices, while Obstfeld and Rogoff (84) explore the effect on exchange rates of various sticky price adjustment assumptions.

The role of wages in determining prices and the interaction between prices and wages has been included in some exchange rate modelling. Bruno (78) developes a price determination equation with both a "cost push" component, in which wages play an important role, and a "demand pull" component, and Dornbusch (82) and (83), Chan (79) and Sachs (80) all include wages in their price determination equations.

Finally, the persistent inflation of the seventies has fostered interest in models with a long run steady state rate of inflation. Frankel (79) and Buiter and Miller (81) present such steady state inflation models, which result in a proportionate changing of the long run exchange rate over time; the real exchange rate is constant in the steady state, but the nominal exchange rate is not.

N. Purchasing Power Parity

Due to the fact that the evolution of the doctrine of Purchasing Power Parity (PPP) was discussed in subsection II.C. of this chapter, the present subsection will only deal with recent work based on, or related to, PPP.

Useful surveys of PPP related studies are found in Isard (78), and Officer (76). Isard distinguishes four recently common versions of the doctrine. The first three versions concentrate on parity of goods prices and assume that the pressure that keeps PPP in tact comes from buyers of goods, producers of goods, and arbitragers, alternately. The fourth version centers on parity in asset market prices, postulating equality of real interest rates among countries. Models that include PPP are found in Dornbusch (73), Helpman and Razin (82), and Obstfeld (81), to name but a few.

Empirical work on PPP has been extensive during the present float, and by and large the evidence is in favor of rejection of the doctrine. Dornbusch (80 BP, p. 151) presents regressions on the basis of which he concludes that the "link between the exchange rate and PPP fails to hold", while Stockman (80) studies percentage deviations from PPP over the first two thirds of this century and finds that (p. 675) "It is apparent that deviations from purchasing power parity persist over time and that exchange rates vary more than ratios of price indexes." Frenkel (81) provides evidence that deviations from PPP are much less between European countries than between those European countries and the USA--on the basis of which he concludes that deviations from PPP are affected by geographical proximity. Isard (77 p. 4) argues that PPP will only hold when the goods whose prices are under consideration are "close to identical, or near perfect substitutes", and he provides empirical support for this hypothesis. Kreinin and Officer (78) survey studies of adherance to PPP in goods markets, bonds markets, and equity markets, finding that most of the work in all three areas rejects the PPP doctrine.

Several authors have modelled deviations from PPP. Aizenman (84) presents a model in which (p. 187) "Deviations from the law of one price are closely related to the total variability in the economy...." Niehans (81) goes a step further than the common scenario in which deviations from PPP are the result of real shocks to the economy, developing a model for which (p.67) "The main conclusion from this analysis is that even in the case of purely monetary disturbances there is, except in special cases, no reason for equilibrium exchange rates to correspond to PPP." Dornbusch (76 JPE) contains a model in which short run deviations from PPP are the result of sticky prices and consequent goods market disequilibrium. Isard (78) and others have discussed the effect of the relationship between tradable and nontradable goods on PPP. Finally, Kimbrough (83) presents a model in which short term deviations from PPP allow markets to stay in continuous equilibrium while adjusting to unanticipated shocks.

O. Other Components for Modelling

There are, of course, many more characteristics of modelling that could be considered--I have attempted here to concentrate on characteristics of prime importance. That is not to say, however, that those aspects of modelling that have not been discussed above are insignificant. Pearce (61) has pointed out that the choice of whether to develop a model in absolute or relative (in terms of a numeraire) terms can seriously impact the applicability of the model. Chan (79), Helpman and Razin (82 JPE), Lapan and Enders (83), and Obstfeld (81) all pay special attention to the effect of planning horizons on modelling. Baron (76), Eaton and Turnovsky (84), Friedman, Harrison, and Salmon (84), and Harris (81) all study the impact of inclusion of forward foreign exchange markets on spot rate modelling. The effect of oil prices, especially on the exchange rate of an oil producing country, is studied in Beenstock, Budd and Warburton (81), Buiter and Miller (81), Cordon (81), and Hacche and Townend (81). The list of possible extensions is endless, but we will leave it at this point.

VII. Dynamics and Stability

Much attention has been given to study of the dynamics generated by various models. Indeed, in many cases, models are developed with their dynamics as a primary consideration. Central to the study of dynamics is the idea of stability, for the stability characteristics determine how, when, and if the economy or economies described by the model will return to equilibrium after perturbation. The stability of a given model is identified by studying that model's dynamic equations--those equations that specify adjustment paths for variables in the model. A model can contain no dynamic equations (in which case it is an equilibrium type model in which the economy under study is assumed to respond to a shock with instantaneous adjustments that restore equilibrium immediately) or an infinite number of dynamic equations, the complexity of the analysis increasing exponentially with the additon of each dynamic equation.

The simplest type of dynamics result when the model contains only one dynamic equation. Given a dynamic equation of the form,

$$\dot{x} = ax + b$$

(where $\dot{x}$ is the rate of change in the variable x) it is easy to see that the system of which this equation is a part will be stable if a is negative. If a is negative then a one time disturbance resulting in a rise in x above its equilibrium level will result in a negative $\dot{x}$, representing a fall in x bringing it back toward its original equilibrium level where $\dot{x}=0$. On the other hand, if a is positive, a rise in x results in a positive $\dot{x}$, and x will grow explosively as a result of a one time shock. If a is zero then the dynamic equation represents a simple time path: x will grow at the constant rate b.

Models containing one dynamic equation are found in Bhandari (81) and (83), Blejer (77), Chan (79), Dornbusch (76 JPE), Dornbusch and Fischer (80), and Mussa (82). As was mentioned earlier, perhaps the most celebated result of any of these one dynamic equation models is Dornbusch's overshooting hypothesis which came out of his assumption of sticky prices and short term goods market disequilibrium. This means that in the short run the exchange rate is dominated by asset markets, which are always in equilibrium, leaving the goods market to come into play in the long run. Bhandari (83) obtains overshooting by assuming not that prices are sticky, but that price elasticities of demand are different in the short and long terms and follow an adjustment path dictated by his one dynamic equation.

The analysis is complicated considerably when two or more dynamic equations are involved. The short hand versions of equations R1 and R2 may be used to demonstrate the complications that arise:

(R1) $\ln\dot{R} = w\ln R + x\ln R_f + A$

(R2) $\ln\dot{R}_f = y\ln R + z\ln R_f + B.$

If either of these dynamics equations were being analysed in a setting in which it was the only dynamic equation, then it would simply be the sign of w or z that would matter.

When the two dynamic equations are combined in one model, however, the interaction between the two dynamic equations must also be considered. If w and z were both negative, for instance, but y and x were of large enough magnitude and of the same sign, a disturbance to lnR could lead to a still larger disturbance to $\ln R_f$ (transmitted through the $x \ln R_f$ term in equation R1). Instead of returning to equilibrium, the system might explode.

For the two dynamic equation case, the characteristics of the four coefficients w, x, y, and z that will result in the various possible classes of stability are summarized in the determinant D (where D = wz - ky below) and trace,T, (the trace being the sum of the elements on the main diagonal, or w + z) of the two by two matrix F:

$$F = \begin{bmatrix} w & x \\ y & z \end{bmatrix}.$$

The values of D and T that will produce each of the four possible classes are,

1) Universal Stability* when $D \geq 0$ and $T < 0$,
2) Instability when $D \geq 0$ and $T > 0$,
3) Non-convergent stability when $D > 0$ and $T = 0$,
4) Saddlepoint stability when $D < 0$.

Figure 1 taken from George and Oxley (83) illustrates what the paths of the two dynamic variables would look like given the possible combinations of D and T.

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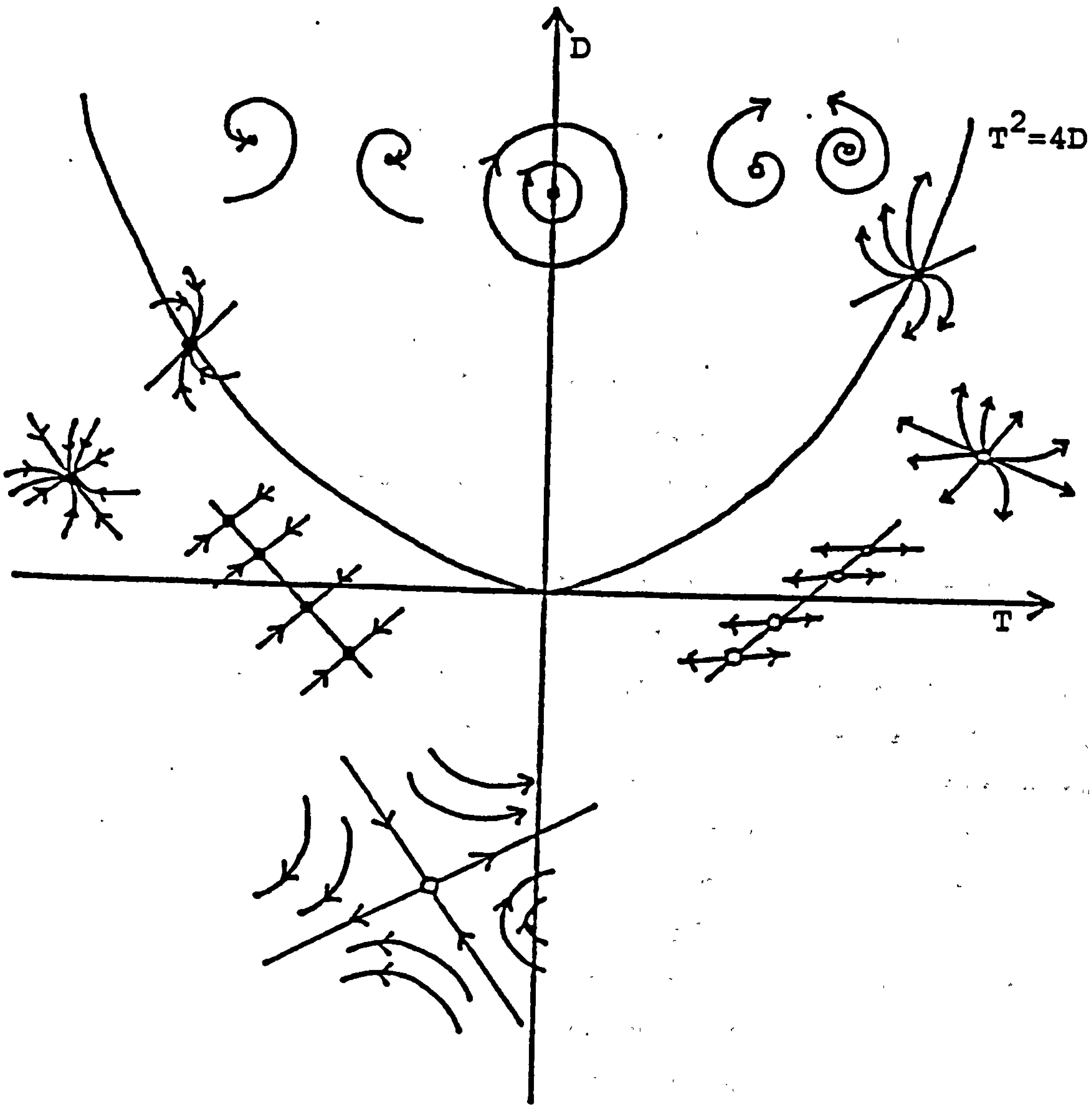
*As used here, universal stability has nothing to do with the idea of global stability, but refers to the case in which a model displays only convergent dynamic paths in the universe (which may be only local) under study.

Figure 1



● Stable Equilibrium

○ Unstable Equilibrium

Those phase portraits in the upper right quadrant and on the D=0 line to the right represent unstable systems--once the system is perturbed from equilibrium it will explode.

That phase portrait on the upper half of the T=0 line represents systems displaying what Samuelson (47) has termed stability of the second kind or oscillatory neutral stability (stability class 3 above). As Samuelson has pointed out, (p.262) this is the kind of stability involved when "one displaces a frictionless pendulum, it will oscillate endlessly around the position of stable equilibrium." A model displaying this kind of endless cyclical behavior might be desirable, but non-linear modelling probably represents an easier way to obtain this cyclical behavior.

Phase portraits that represent various models having universal stability (class 1) are illustrated in the upper left quadrant of figure 1 and on the left side of the D=0 line. Perturbation of such a model in any direction will put the system on one of the infinite convergent paths resulting in restoration of equilibrium in the long run. Historically, models displaying this kind of stability have been considered (from the dynamics point of view) reasonable representations of reality--or in any case preferable to models displaying stability types 2 or 4. For any given perturbation, one of the infinite convergent paths is automatically chosen and followed until the system is returned to equilibrium.

Recently, however, members of the Rational Expectations School have taken issue with this traditionally held view, arguing that models displaying stability of type 4--saddle point stability--are more in keeping with reality than universally stable models. A representative phase portrait of a model with saddle point stability is illustrated in the lower half of figure 1, its key feature being the unique convergent path.

Begg (82) argues that, for rational expectations modelling, saddle point stability is more attractive than universal stability because saddlepoint models exhibit unique paths for convergence to the steady state. Two crucial assumptions are involved in coming to the conclusion that saddlepoint stability is preferable. First, more than one (the exact number is discussed below) of the dynamic variables must be controlled by speculators or some other agents in the economy. These variables are often called "jump variables" because, although they have specified adjustments paths, they are assumed to make discrete jump adjustments if those in control of the jump variables desire such discontinuous adjustment. The second assumption on which Begg's conclusion is based is that speculators will choose to place the economy on a convergent path (this assumption will be discussed below).

Assume, for instance, a saddlepoint model with two dynamic equations, one of the dynamic variables being the exchange rate which speculators control. If a speculator assumes that all other speculators want to achieve equilibrium and that together, all of the speculators will be able to move the exchange rate exactly where they want it, he will be able to form expectations of future movements of the economy on the basis that the unique stable path will be jumped to and then followed--which indeed it will be if his assumptions are justified. Begg argues that models of stability class 1, universal stability, are not as desirable in this case, since they contain an infinite number of paths to equilibrium, any of which could be chosen and achieved, and consequently (p. 36), "expectations formation will prove extremely difficult."

As George and Oxley(83) and (85) have pointed out, however, the assumption that economic agents wish to move the economy to equilibrium must be viewed as auxiliary to the rational expectations hypothesis. Most often included via the transversality condition, this assumption is used to insure that the required number of boundary conditions will exist to define a unique path the economy will follow. A system with n dynamic equations (and therefore n dynamic variables) requires that n independent boundary conditions must be specified to uniquely determine the path of the economy. The boundary conditions may all be initial conditions, all terminal conditions, or some combination of the two. Initial conditions cannot, of course, be defined for the jump variables. Therefore even if initial conditions are given for all of the non-jump dynamic variables, one terminal condition must exist for each jump variable in the system. Unfortunately, there is nothing in the rational expectations hypothesis that will provide these required terminal conditions and so the transversality condition or the assumption that economic agents wish to move the economy to equilibrium are invoked to fill this need.

As the debate over the relative virtues of universal stability (stability class 1) and saddlepoint stability (stability class 4) continues, dynamic models of each type are being generated. Two dynamic equation models that exhibit universal stability can be found in Branson (79), Frenkel and Rodriguez (75), Niehans (77), Turnovsky (81), and Rodriguez (81). Buiter and Miller (81), Gray and Turnovsky (79), Liviatan (81), Obstfeld and Rogoff (84), and Turnovsky (81) contain dynamic models with saddlepoint stability.

For models with more than two dynamic equations, more general criteria must be used to determine stability type. For a model with M dynamic variables (and therefore M dynamic equations) if there exist M stable (negative) characteristic roots the model will exhibit universal stability, if there exist M unstable (positive) characteristic roots the model will exhibit instability, and if there exist both stable and unstable characteristic roots the model will exhibit saddlepoint stability. For a dynamic model with saddle point stability with M dynamic variables and N unstable roots, there must exist N jump variables if, after a given perturbation, those in control of the jump variables are to be able to attempt to put the system on the path to equilibrium. If more than M-N variables are predetermined or "backward looking", those in control of the jump variables will be unable to jump the economy to the stable path, and the system will (at least locally) explode. If, on the other hand, more than N jump variables exist, those in control of the jump variables will have an infinite number of convergent paths to choose from and expectations formation will again prove difficult. Using these generalised stability criteria, it becomes obvious that universal stability, in which case N=O, and instability, in which case N=M, are the two extreme cases bounding the hybridised saddle point case.

Studies of the dynamics of models with three or more dynamic equations are found in Bhandari (82), Chen (74), Neary and Purvis (82), Tsiang (75), and Tower (77).

VIII. Empirical Work on Various Exchange Rate Models

Empirical work on individual aspects or components of modelling exchange rates has been presented in the subsections discussing those components and will not be dealt with here. There have, however, been a number of empirical studies reported which estimate and/or compare models made up of various combinations of these components and which deserve mention at this point.

Starting at the simplest level, Giddy and Dufey (75) compare models of the exchange rate as determined by: 1) a random walk; 2) uncovered interest parity (the expected change in the exchange rate is equal to the interest rate differential between the two countries); 3) the forward rate hypothesis (that the forward exchange rate is an accurate predictor of future values of the spot rate); 4) Box-Jenkins analysis; and 5) Box-Jenkins type analysis with exponential smoothing. The authors refer to the first two models as efficient markets type, and find that in general neither of them is rejected by the other three models. In fact (p. 27), "Of the five methods, the forward rate is consistently inferior to all the others." They conclude that the efficient markets hypothesis cannot be rejected on the basis of their study, and that (p. 29) "the results provide support for the notion that trading rules are of no use in forecasting exchange rate changes." These conclusions are also supported by the results of studies reported in Logue, Sweeney, and Willett (77). Seemingly at odds with Giddy and Dufey, Frenkel (81) presents evidence, on the basis of which he concludes (p. 672) "that the use of the forward exchange rate as a proxy for expectations does not introduce a significant errors in variables bias"--though he does not compare the forward rate based model with other models to see if more explanatory power could be found.

Shafer and Loopesko (83) provide evidence that the percentage of the variance in the exchange rate accounted for by the variance in relative output, relative prices, relative money supply, interest rate differential, and the trade balances of the countries, differs greatly between the dollar/mark, dollar/yen, and dollar/sterling exchange rates.

With the monetary model of exchange rate determination in mind, Caves and Feige (80), Frenkel (76) and Katz (83) study the relationship between the exchange rate and money supplies for various pairings of countries. All three studies provide evidence of correlation between the exchange rate and money supply. On the basis of the significance and size of coefficients of future values of money supply in their regressions, however, Caves and Feige conclude that at least some of the causality runs from the exchange rate to the money supply (which as they point out (p. 131), "is consistent with the hypothesis of government intervention in the foreign exchange market").

Dornbusch (80 BP) reports empirical work on the monetary approach to exchange rate determination, using data from the USA and West Germany, and concluding that the equation estimated has negligible explanatory power. Dornbusch uses autoregressive techniques without attempting to identify whether the autocorrelation present is a result of autocorrelation in the 'true' model or dynamic misspecification, a shortcoming which will be discussed in more detail in the next chapter. He also introduces the dependent variable with a lag as an explanatory variable, finding it to be the only variable whose estimated coefficient is significant at any reasonable level. Indeed, out of four estimated equations, in which 14 coefficients were estimated, only two estimated coefficients were highly significant.

Edwards (83) obtains better results in his estimation of the monetary model--though he assumes that some of the coefficients follow (p.78) "a third order polynomial with zero end constraint" and imposes an 18 month lag. This is surely an example of what Courakis (78, p.538) had in mind when he referred to "Higgledy-Piggledy model building."

Surveys of empirical work on the monetary approach to the balance of payments are found in Kreinin and Officer (76), the conclusions being well mixed.

Backus (84) presents, estimates, and empirically compares a spectrum of exchange rate determination models, ranging from the simple random walk and PPP models through the monetary model and a portfolio balance model, in a reasonably meticulous study. Unlike most others, he does tests to determine whether the autocorrelation found in a given model is the result of dynamic misspecification. He uses log-likelihood functions to compare nested models and the relatively new Davidson and MacKinnon (81) tests (which are discussed in some detail when they are applied in the next chapter) for comparing non-nested models. He finds that the random walk performs as well or better than some of the more complicated models, but in general the more sophisticated models tend to outperform the less sophisticated models.

Hacche and Townend (81) also present and estimate a variety of the recent models of exchange rate determination--though their techniques stand up less well under scrutiny than those of Backus (as will be discussed in the next chapter). Autoregressive techniques were used without tests as to their appropriateness and the estimates of the various models are not explicitly compared. Still, their estimations of several models with a consistent data set represents a useful contribution to the small pool of empirical work done on exchange rate determination models.

Driskill (81) formulates the Dornbusch (76 JPE) model and a stock flow model so that the same coefficients must be estimated for each of the models. Because the two models predict different signs or magnitudes for the coefficients, estimation (using U.S. and Swiss data) allows him to choose the stock flow model over the Dornbusch model as having its predictions more closely supported by empirics. Tronzano (81) estimates Driskill's two equations using U.S. and Italian data and also produces results that are consistent with the predictions of the stock flow model and not the Dornbusch model. Frankel (79) uses a similar technique to compare the sticky price Dornbusch model to two flexible price models and one real interest differential type, producing results that are inconclusive and not wholly consistent with any of the models.

Meese and Rogoff (83) compare a flexible price monetary model in which PPP is maintained, with a Dornbusch type sticky price model in which there are deviations from PPP, and a sticky price asset type model. They compare these three on the basis of predictive performance over various forecasting horizons, predictive performance being measured using root mean square forecast errors. None of these structural models is seen to consistently outperform the random walk based model.

As might be inferred from the preceding, empirical work on exchange rate models has in general been insufficient and lacking in rigor. Aside from the study by Backus, there has been a shortage of reasonably comprehensive and careful work in this area. The next three chapters represent an attempt to help fill some of this void, presenting fairly rigorous econometric studies on the monetary, Dornbusch, and stock-flow type models.

The Monetary Model

I. Introduction

This is the first of three primarily empirical chapters which undertake reasonably rigorous econometric analysis of three common models of exchange rate determination, namely, the monetary, Dornbusch, and stock/flow models.

A fairly mainstream version of the monetary model is formulated in section II. A brief justification for doing empirical work on the arguably unrealistic monetary model is made in section III, and problems with finding appropriate data are discussed in section IV. Section V represents the bulk of the chapter, consisting of replication of the results of an earlier econometric study on the monetary model and tests for dynamic misspecification, structural breaks, and sensitivity of the results to the data set used. Section VI concludes and summarizes.

II. Development of the Simple Monetary Model

The simple two-country monetary model is built from the assumption that all markets are in equilibrium at all times. Further, it is assumed that money is the only internationally traded asset. Given the money demand function:

(1) $M^d = \alpha P^{\beta} Y^{\gamma} e^{-\delta i}$

where β is usually assumed to be equal to unity. Money market equilibrium implies that (switching to log form):

(2) $\ln M \ (=\ln M^d) = \ln\alpha + \beta \ln P + \gamma \ln Y - \delta i$

in the case of each country.

The assumption of flexible prices means that relative purchasing power parity holds:

(3) $S = \mu(P_f/P), \quad \mu = \text{constant}$

where the exchange rate, S, is foreign/domestic currency units throughout this paper.

Combining the domestic and foreign counterparts of equation (2) with equation (3) gives:

(4) $$\ln S = K + \frac{1}{\beta_f}\ln M_f - \frac{1}{\beta}\ln M - \frac{\gamma_f}{\beta_f}\ln Y_f + \frac{\gamma}{\beta}\ln Y + \frac{\delta_f}{\beta_f} i_f - \frac{\delta}{\beta} i$$

where all coefficients are given their <u>a priori</u> signs.

Given exogenous money supplies, exogenous income levels (full employment level assumed), exogenous foreign interest rate, and exogenous domestic interest rates via the assumption of perfect capital mobility and exogenous expectations of exchange rate changes, $E(\hat{S})$,

(5) $i_f - i = E(\hat{S})$

and only the exchange rate and the domestic price level are endogeneous to the system.

Thus, a rise in the domestic money supply cannot be accomodated by changes in the income level or interest rate, and instead, equilibrium is maintained via a tatonnement adjustment of the price level upwards (inflation) and the exchange rate downwards (depreciation).

If money is neutral then the coefficients of $\ln M_f$ and $\ln M$ will be one and negative one, respectively, and the coefficients of all other variables will likely be between zero and one in absolute value.

III. Reasons for Estimating the Simple Monetary Model.

It might be argued that the full equilibrium environment of the simple monetary model just presented is so unrealistic that it does not warrant empirical testing. From the assumption of purchasing power parity to that of full employment income, goods market equilibrium and perfect capital mobility, the model seems overrun with components that do not appear to correspond to the real world.

Yet, econometric work on this model can be seen as worthwhile for two reasons. First, scientific method requires that empirics are the cutting edge of inquiry, providing the basis for distinguishing between acceptable and unacceptable theories. Granted, there is ample evidence of the lack of realism in assumptions of short-run flexible prices, perpetual full employment income, and purchasing power parity. The question is whether these and the other assumptions approximate reality closely enough to combine to produce a model which adaquately describes or explains the phenomenon under study--that is, in the tradition of Friedman and Machlup, whether the exchange rate behaves "as if" these assumptions were true. If the lack of realism in the assumptions making up the monetary model is serious enough to preclude the model from being a reasonable representation of reality, then econometric testing should bear out this fact.

Second, the monetary model continues to be widely used at the time of this writing. This may be due in a large part to the lack of empirical work on this and other models. As long as members of the economics profession continue to use the monetary model, a case can probably be made for empirical research aimed at support for or rejection of this model.

IV. Data

The first goal of estimation of the monetary model was to replicate the regression reported by Hacche and Townend (81), hereafter H&T. H&T used 70 periods (January, 1972 -October, 1977) of monthly date to estimate an equation of the form of (4) seeking to explain the United Kingdom's effective exchange rate, EER, (17 country, MERM* weighted average) in terms of the MERM weighted average seasonally adjusted money supplies of five major industrial countries (France, W. Germany, Italy, Japan, and USA), M_f, the MERM weighted average seasonally adjusted income of those five countries, Y_f, the London Eurodollar interest rate (as a proxy for the five country, MERM weighted average interest rate), i_f, and, of course, the seasonally adjusted money supply, M, income, Y, and interest rate, i, of the UK.

Identifying and finding data which was consistent and seemed appropriate for the model--much less, similar to that used by H&T--proved somewhat difficult. Although in the end a copy of H&T's data was obtained and used in replication, it is clear that there are many possible sources of data problems in this estimation. Some of these potential problems are listed below. All data used in estimations reported in this paper are presented and discussed in an appendix at the end of this paper.

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*MERM stands for the Multilateral Exchange Rate Model of the IMF in Artus and Rhomberg IMFSP, Nov., 1973, pp 541-611. "The weights derived from the MERM are such that any combination of changes in other currencies against sterling (the home currency) which would have the same effect on the UK trade balance as a one per cent change in sterling against each of the other countries currencies is reflected as a one per cent change in the index." Bank of England Quarterly Bulletin, March, 1981, p. 69.

1) Five country MERM weighed averages were used for M_f and Y_f as proxies for their seventeen country counterparts; the latter being appropriate since the seventeen country EER was used (all data necessary for calculation of the seventeen country counterparts are not available on a monthly basis.)
2) MERM weights are trade based. While it is true that goods markets are also in equilibrium in this model, it is usually the asset market equilibrium aspect of the model which is emphasized. In any case, asset market equilibrium is as much as part of the model as goods market equilibrium, and capital flow based weights may therefore be at least as relevant.
3) The money supply statistics reported by the IMF (H&T's source) in International Financial Statistics (IFS) appear to differ greatly with those reported by the OECD in OECD Financial Statistics (OECDFS). It is not clear which publication bears the more appropriate money supply statistics -- though it may be noted that inspection indicates that the OECDFS data bear a much closer resemblance to statistics reported by the five countries' central bank publications than do the IFS data. This discrepancy is largely explained by the following excerpt from a letter from Werner Dannemann, Director, Bureau of Statistics, IMF, dated June 1, 1983:

"IFS attempts to define money and quasi money uniformly for all countries. Broadly speaking IFS defines money as those obligations of the monetary authorities and the deposit money banks that are usable as a means of payment, i.e. the currency outside banks and demand liabilities to residents reported by the monetary authority and the deposit money banks. The central government's holdings of currency (if available) and the central government's deposits at the monetary authority and the deposit money banks are excluded from the IFS definition of money because it is assumed that the central government is not subject to the same liquidity considerations as are the other sectors of the economy.

Quasi-money as defined in IFS comprises the deposits with the monetary authority and deposit money banks (of nonbank residents excluding the central government) that are not directly usable as a means of payment but are withdrawable at the holder's initiative."

4) Sterling M3 and M3 were used for M and M_f, respectively. It is not clear which money supply measure (M1, M2, M3, for instance) is most appropriate. The inclusion of money via the money market equilibrium equation (in which the interest rate is seen as the price of holding non-interest bearing money) in all three models studied here (monetary, Dornbusch and stock/flow) might lead one to believe that mostly non-interest bearing M1 would be most appropriate. The question of appropriateness is muddled in the stock/flow model, however, where the demand for various currencies is seen to depend on their relative expected yields--implying interest bearing money should be used. I will follow H & T and use sterling M3 since the first goal of this study is replication of their results.

5) The 3-month sterling interbank rate and London Eurodollar rate were used for i and i_f, respectively. It is not clear which interest rate (or interest rate composite) is most appropriate.

6) The London Eurodollar interest rate may not be a good proxy for the foreign country weighted average interest rate.

7) The appendices for the periodical version of IFS seem to indicate that some of the countries may have changed the components of money supply and industrial production (income proxy) used over the period estimated by H&T.

The above list is by no means exhaustive. It has been argued (see Leamer (85)) that all data problems such as the above must be resolved--or at least presumed to be resolved--before any estimation is undertaken. The idea is that all candidates for the data to be regressed can be discriminated between and ranked in worthiness on the basis either of theoretical appropriateness (as in problems 1, 2, 4, 5, and 6), or of integrity in statistical collection (in the cases of problems 3 and 7).

Methodologically, it would be hard to disagree with this point. Unfortunately, theory is often not clear cut enough--or overwhelmingly enough agreed upon--to serve this discriminating role. For instance, theoretical arguments might be made for the use of M1, M2 or M3 data in the regression. Neither is it always possible to become familiar enough with the methods of the data collection and treatment of various data sources as to allow for discrimination on the basis of statistical integrity. Given these two practical problems, the empiricist seems to have three possible courses of action: 1) become a theoretician, or find an empirical problem where these practical problems are not encountered; 2) presume to be able to resolve any data problems and thus, report the results of empirical study as if all such problems were satisfactorily resolved; 3) present such problems as part of the work, along with attempts at their resolution, and study, where possible, the seriousness of the discrepancies between the various data candidates to the outcome and conclusions of the work.

The first of these is simply avoidance of the problem. Given that the study is to be carried out, the choice is between the second and the third. To the author, it seems that while the second course may appear more true to the "letter of the law" of scientific method, the third is clearly more true to the "spirit of the law." While the second presents a picture which more closely corresponds to what scientific research is supposed to look like, it is the third which is in fact more faithful and scientifically sound.

To the criticism that the same data may not be used to econometrically test, and rank various data sets relative to appropriateness and then to test the model in question, the author submits. The choice of data should not be made on the basis of which data gives the best result when used in estimating the model. This procedure presupposes the validity of the model and is simply data mining.

Instead, the following procedure is proposed--and followed in this paper. As in the second course of action above, one set of data is singled out as possibly or probably most appropriate for the model. Then, in the cases of variables with more than one "possibly appropriate" data sets (which are not clearly rankable owing to indefinitiveness of theory or lack of information relative to data collection procedures of various data sources), the equation should be reestimated using the other candidate data sets to test the sensitivity of the regression to the change in data used. While this procedure would not allow one to choose which data set is most appropriate, it would seem to make the issue of appropriateness irrelevant in cases where the regression was insensitive to the choice of data set. Thus the sensitivity studies would only give an indication as to the strength with which any conclusions of the study might be stated. Evidence of sensitivity of the regression to the choice between equally feasible data sets would detract from the conclusiveness of the study.

V. Econometric Work on the Simple Monetary Model

A. Replication of Hacche and Townend's Estimation

Equation 1M (t-statistics in parentheses) is the Ordinary Least Squares (OLS) version of the equation estimated by H&T (they only reported the autogressive estimation). Both the Durbin-Watson statistic of .923 (d_L=1.46 at the 95% level for k=6 and n=70) and the plot of residuals (not shown) indicated that autocorrelation was present in the estimation. This result was consistent with the findings of H&T.

$$(1M)\quad \ln EER = \underset{(3.76)}{-6.25} + \underset{(5.36)}{.711}\ \ln M \underset{(9.49)}{-1.477}\ \ln M_f + \underset{(.077)}{.007}\ \ln Y -$$

$$\underset{(4.00)}{.345}\ \ln Y_f - \underset{(7.80)}{.031}\ i + \underset{(5.92)}{.011}\ i_f$$

$\bar{R}^2$ = .986 se = .019 DW = .923 LLF = 183.32

The equation was then reestimated using Cochrane-Orcutt autoregressive techniques to obtain equation 2M. This estimation very closely resembles the autoregressive estimation reported by H&T, as indicated in table 1M.

$$(2M)\quad \ln EER = \underset{(.097)}{.193} - \underset{(.320)}{.055}\ \ln M - \underset{(4.51)}{.941}\ \ln M_f - \underset{(.065)}{.005}\ \ln Y +$$

$$\underset{(.151)}{.025}\ \ln Y_f - \underset{(4.87)}{.008}\ i + \underset{(1.29)}{.003}\ i_f + \underset{(22.89)}{.940}\ U_{t-1}$$

$\bar{R}^2$ = .992 s.e. = .014 DW = 1.808 LLF = 201.64

Given what appears to be successful replication of H&T's autoregressive result, this study reverted to equation 1M, the OLS version, for the baseline from which extensions were to be made. The OLS estimation was seen as preferable to the autoregressive estimation for the purpose of extensions for two reasons. First, unless the value of ρ (the coefficient of U_{t-1} in equation 2M) were constrained to some constant value throughout the regressions to be compared, it would likely vary over the regressions and the regressions would not be comparable.

TABLE 1M

Variable	Coeff's (t-stat) Estimated by H&T		Coeff's (t-stat) Estimated in Replication Attempt	
Constant	+.120	(.060)	+.193	(.097)
ln M	-.054	(.306)	-.055	(.320)
ln M_f	-.941	(4.214)	-.941	(4.508)
ln Y	-.003	(.034)	-.005	(.065)
ln Y_f	+.035	(.182)	+.025	(.151)
i	-.008	(4.747)	-.008	(4.872)
i_f	+.003	(1.295)	+.003	(1.294)
U_{t-1}	+.942	(22.546)	+.940	(22.886)
	$\bar{R}^2$=.992, s.e.=.014, DW=1.805		$\bar{R}^2$=.992, s.e.=.014, DW=1.808	

Second, adoption of the autoregressive estimation as the baseline would imply the

assumption that the monetary model represents the "true" model and that this true model exhibits autororrelation --as opposed to the alternative hypothesis that the monetary model is misspecified. This second point will be studied in more detail in section V.B.

Since the data received from H&T extended through 98 periods (January, 1972 to February, 1980), it was decided that the OLS estimation would be repeated using the larger data set so as to give a baseline estimation with more degrees of freedom than those of equation 1. Equation 3M is the result of this 98 period OLS estimation. Comparison of equations M1 and M3 indicates that the additional 28 periods of data included in the regression resulting in equation 3 had a far from trivial effect on the estimation. Further discussion of this result will take place in section V.D.

$$(3M)\quad \ln EER = \underset{(5.77)}{13.583} - \underset{(5.41)}{1.004} \ln M + \underset{(2.87)}{.602} \ln M_f + \underset{(.706)}{.133} \ln Y -$$

$$\underset{(.473)}{.901} \ln Y_f + \underset{(.940)}{.003}\, i + \underset{(11.92)}{.032}\, i_f$$

$$\bar{R}^2 = .914 \quad s.e. = .046 \quad DW = .577 \quad LLF = 166.66$$

B. Investigation of Autocorrelation and the Possibility of Misspecification

As mentioned in section IV.A., H&T's reporting of the autoregressive estimation of the monetary model implied the assumption that the monetary model is the true model and that this true model exhibits autocorrelation. Hendry and Mizon (78) have pointed out (while critisizing an earlier paper by Hacche (74) for a similar assumption) that this assumption can be tested to some extent in the following manner.* In the case of the independent variable, x, and one dependent variable, y, the above assumption can be seen to be related to the choice between the following three formulations:

A) $y_t = \gamma_o x_t + u_t$

B) $y_t = \gamma_o x_t + v_t/(1-\beta L) = \gamma_o x_t + u_t$
where $u_t = v_t/(1-\beta L)$ and L is the lag operator,

C) $y_t = \beta y_{t-1} + \gamma_o x_t + \gamma_1 x_{t-1} + v_t$

Formulation A is the simple, unlagged, OLS version of the model, and is comparable to equations 1 or 3 of section V.A. Formulation B assumes that the coefficients of y_t and x_t have (Hendry and Mizon, p.550)

> "a common factor of $(1-\beta L)$ and hence the polynomials in L multiplying y_t and x_t have a common root of β."

Formulation B corresponds to equation 2 of section V.A., the autoregressive techniques used in that estimation having incorporated the common root assumption. Formulation C is the most general of the three, reflecting the possiblities that lagged dependent and/or independent variables may be appropriate and that the coefficients of these lagged variables may not share a

*This test was originally proposed by J.D. Sargan (64).

common root. We then have three formulations of the relationship between x and y in gradually increasing order of generalization. The appropriateness of the two restrictions (moving from C to B and from B to A) can be tested using log likelihood ratios or other methods.

Williams' point (78) (in rebuttal to Hendry and Mizon's criticism) that the above technique can provide only necessary, but not sufficient, support for the assumption that one or both of the above restrictions are appropriate detracts little from Hendry and Mizon's argument. True, the above test can in no way prove that formulation A, or B, or C is the true model. The technique can be useful, however, in showing that A or B are not the true models, thereby giving attention to the concern expressed by Hendry and Mizon (p.552) in their statement that

> "In other words, residual autocorrelation may reflect little more than dynamic misspecification, which is a well known but frequently ignored result."

The above is pertinent to the present study since the procedure may be used to test whether estimation of a more general lagged model of the form of equation 4M (the counterpart of C above) produces significantly different results from those obtained in estimation of models of the forms of equations 1M (and 3M) or 2M. If the conclusion of such tests are that such estimations lead to significantly different results, this would be clear evidence of dynamic misspecification in the monetary model, and grounds for rejection of this model in favor of one with more dynamic sophistication.

$$
\begin{aligned}
(4M)\ \ln EER_t = {} & \text{Constant} + \pi_1 \ln M_t + \pi_2 \ln M_{t-1} + \pi_3 \ln M_{f,t} \\
& + \pi_4 \ln M_{f,t-1} + \pi_5 \ln Y_t + \pi_6 \ln Y_{t-1} + \pi_7 \ln Y_{f,t} \\
& + \pi_8 \ln Y_{f,t-1} + \pi_9 i_t + \pi_{10} i_{t-1} + \pi_{11} i_{f,t} + \\
& + \pi_{12} i_{f,t-1} + \pi_{13} \ln EER_{t-1}
\end{aligned}
$$

The 97 and 69 observation (one observation is lost in each case due to lagging) estimations of the unrestructed, first order, lagged formulation (of the form of equation 4M) are reported in the appendix to this chapter as equations 4aM and 4bM, respectively. In the 97 observation case, the log likelihood ratio* comparing the unrestricted first order lagged estimation (4aM) with the Cochrane-Orcutt autoregressive estimation (equation 2aM in the appendix) is equal to 17.28. With the difference in the number of restrictions between the two equations, m, equal to seven, the critical values for this test (the log likelihood ratio has a Chi squared distribution) are 9.04 at the 75% level, 12.0 at the 90% level, 14.1 at the 95% level, and 18.5 at the 99% level. Thus, in the 97 observation case, we reject the hypothesis of a common root at the 95% level, and conclude that there is evidence of misspecification in the monetary model.

The 69 observation case is not as clear cut, the log likelihood ratio of equations 4bM and 2M being equal to 10.84. This means that the hypothesis of a common root can be rejected only at the 75% level giving a much less conclusive result.

In summing up these results, it must be remembered that the log likelihood ratio is assymtotically distributed as Chi squared--the more observations involved, the

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*The log likelihood ratio is calculated as $LLR = 2\ (LLF_G - LLF_R)$ where G = the more general formulation, and R = the more restrictive.

more closely will the log likelihood ratio conform to a true Chi squared distribution. Thus, of the two tests, we would expect that with more observations to be more accurate. It is probably safe, therefore, to conclude that there is evidence of dynamic misspecification in the monetary model. This evidence of dynamic misspecification means that any conclusions from parts D through I of section V must be weak--no strong conclusions may be drawn from a dynamically misspecified model.

C. Investigation of the Sensitivity of the Conclusion of Misspecification to the Data Used

In section IV, it was admitted that a reader of this study might criticize the data used in these estimations and suggest that some or all of the conclusions drawn in this study are a result of this inappropriate data.

It is possible that the data used systematically misses certain important effects, and thus simulates the occurance of omitted variables, resulting in autocorrelation and the possibility of inaccurate conclusion of dynamic misspecification.

In an effort to investigate this possibility in the case of the conclusion of misspecification, the test of misspecification was done two more times. The first re-test used all the data used in the original test except that M1 data were used in place of sterling M3 data for M, and the second re-test used all of the original data, but replaced the 3-month interbank interest rate data with 3-month Paris Eurosterling interest rate for i.

In the first re-test, where M1 was used in place of sterling M3 for the variable M, the log likelihood ratio of the unrestricted first order lagged estimation to the

Cochrane-Orcutt autoregressive estimation was 34.68 for the 97 observation case, and 21.78 for the 69 observation case. When compared with the same critical values as were relevant in the original test (section V.B.) both of these values result in rejection of the null hypothesis of a common root at any reasonable level of significance.

In the second re-test, where the 3-month Paris Eurosterling interest rate was used in place of the 3-month sterling interbank interest rate for the variable i, the log likelihood ratio was 13.96 in the 97 observation case and 9.82 in the 69 observation case. In this re-test, the hypothesis of a common root is rejected at the 90% significance level (narrowly missing rejection at the 95% level) in the 97 observation case, while being rejected at the 75% level in the 69 observation case (again, the same critical values used in V.B. are relevant).

Although both of these re-tests of the misspecification conclusion have indicated rejection of the hypothesis of a common root, the testing of that hypothesis has proved to be somewhat sensitive to changes in the data used. It is possible, therefore, that use of some data set that is arguably appropriate for use in this estimation, would result in no rejection of the common root hypothesis at any reasonable level of significance. As discussed in section IV, however, such an occurance would not indicate that the data set in question was the most appropriate one for the estimation, since this conclusion would imply the assumption that the model is not misspecified. The possibility of this occurance should simply be born in mind when stating the conclusion that the simple monetary model is misspecified.

D. Investigation of the Possibility of a Structural Break*

In section V.A., it was observed that extension of the estimation period of the regression from 70 to 98 periods appeared to drastically change the statistics estimated. It is possible that this discrepency is due, in part or in whole, to the dynamic misspecification of the monetary model. But an argument could also be made that changes in the international economy over the period estimated result in a structural break in the estimation.

The Chow test was used to test the hypothesis of no structural break near the midpoint of the observation period (between observations 48 and 49). The statistic calculated has an F distribution with degrees of freedom 7 and 84 (critical value for (7,90) is 2.12 at the 95% level, and 2.87 at the 99% level). Thus the Chow test value of 13.21 indicates that the hypothesis of no structural break is rejected at the 99% significance level.

Further tests were undertaken to try to identify which of the coefficients from the structural equations were changing over the period estimated, and whether more than one structural break could be identified.

Graphical methods were used to pursue the first of these objectives. The model was estimated using only the first 24 data points, then with the first 27, and 30, etc., and the structural coefficients estimated in each case were graphed to see if they remained reasonably constant over time. Graphs 1M-6M provide evidence that none of the coefficients are constant over the period estimated.

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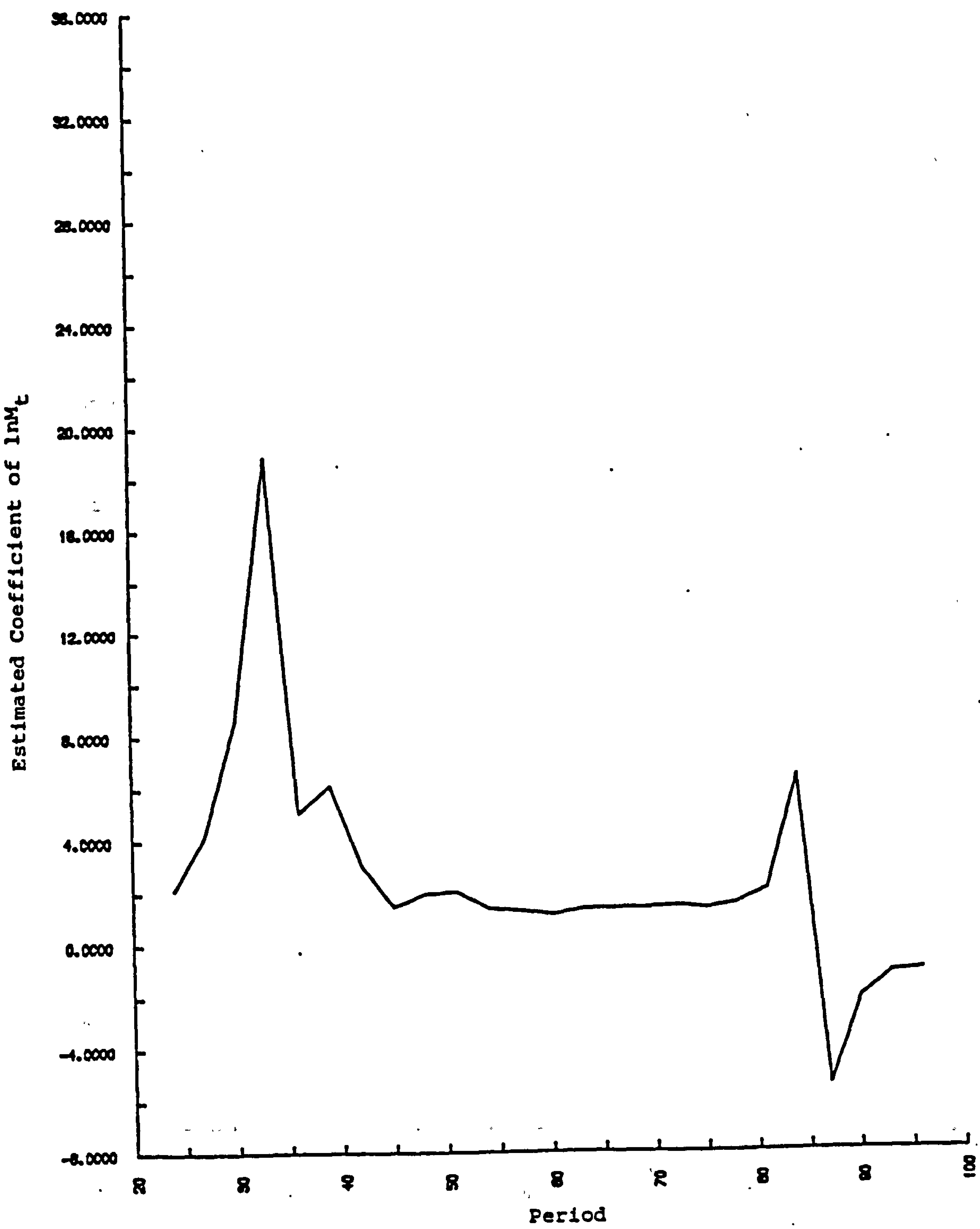
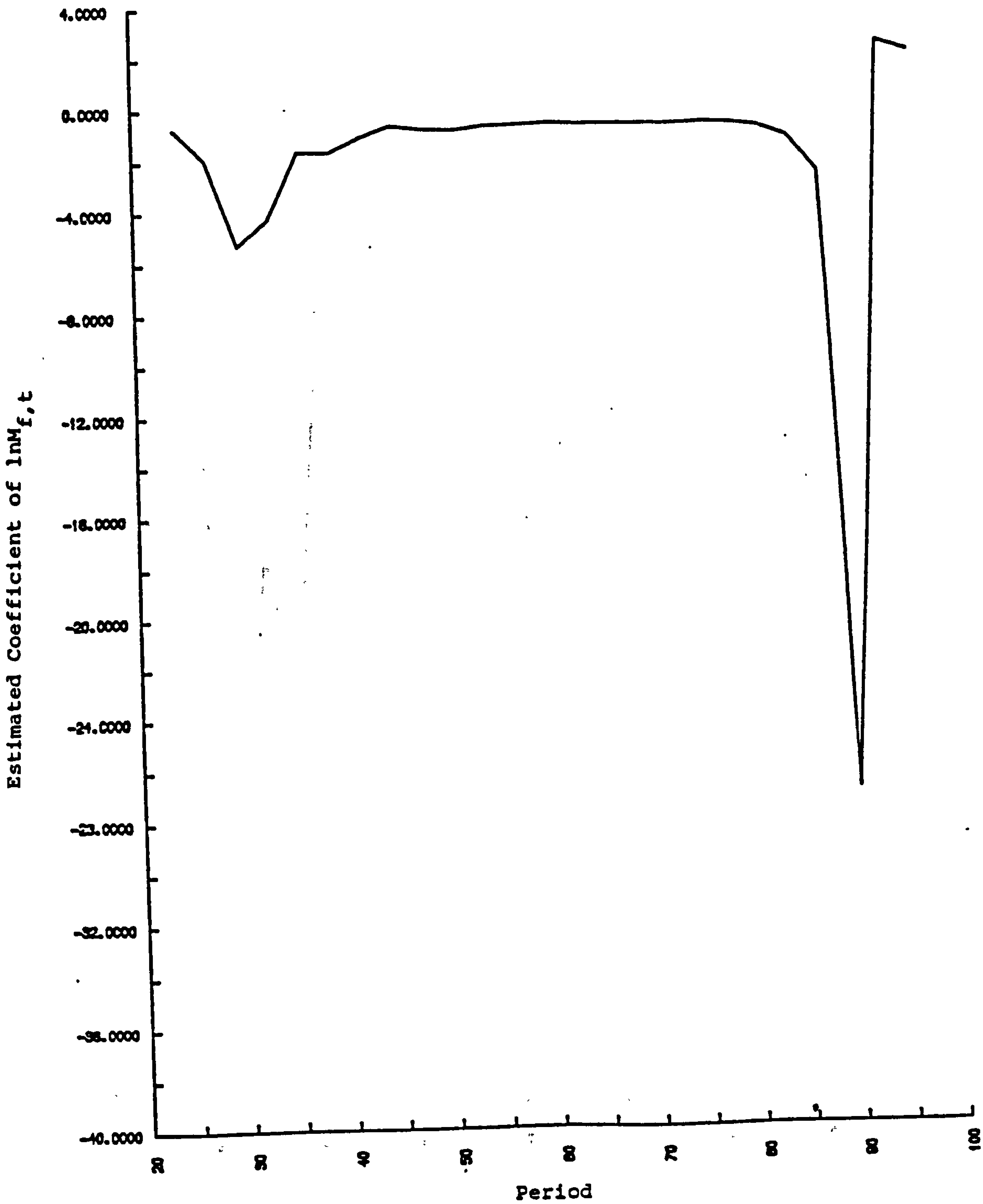
*The quality under study in this subsection is usually referred to as structural stability. I will instead refer to this phenomenon as structural constancy, since it involves the constancy of the coefficients of the model (and so the constancy of the structure of the model) over time.

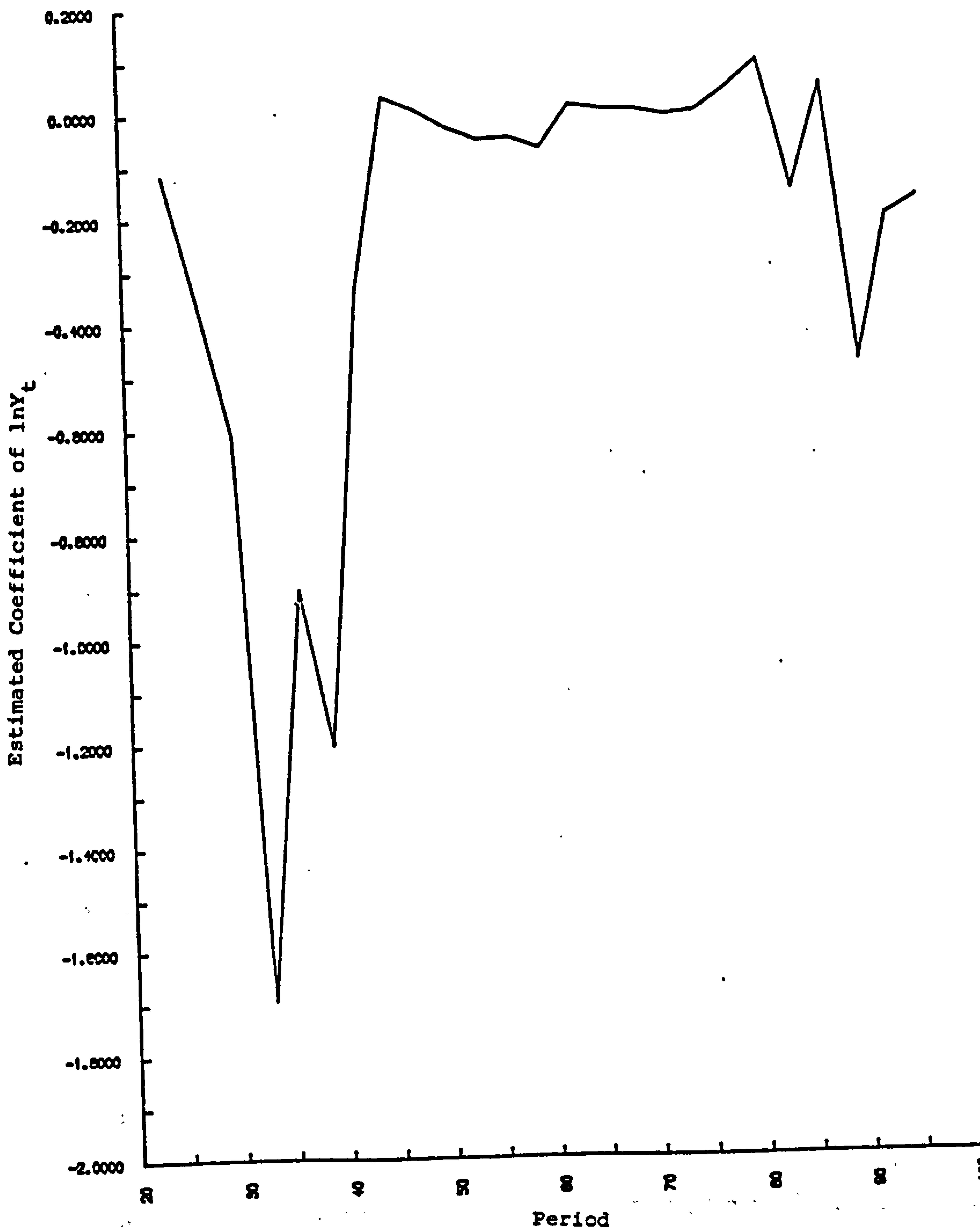
Graph 1M; Variation in the Estimation of the Coefficient of $\ln M_t$ Over Time



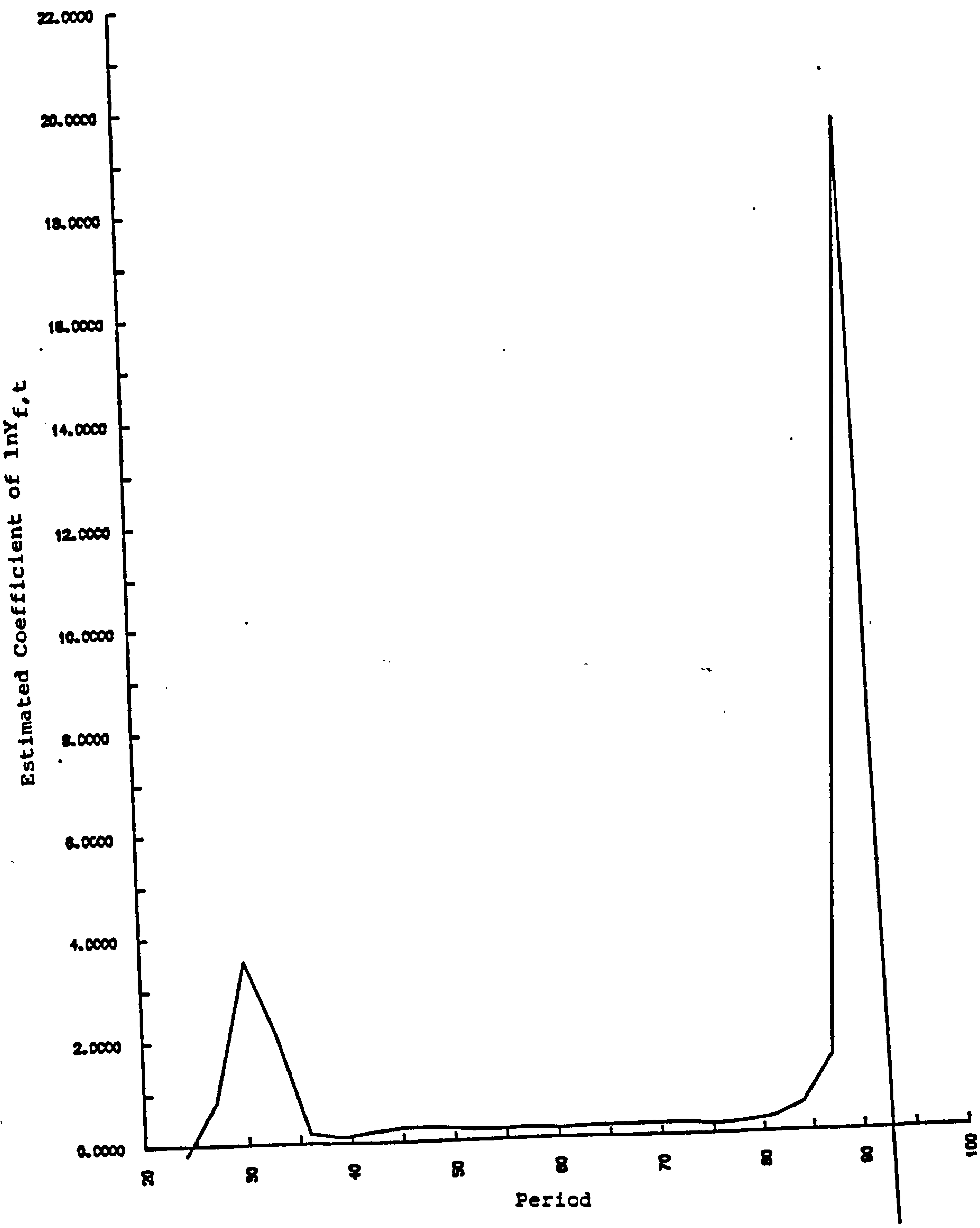
Graph 2M: Variation in the Estimation of the Coefficient of $\ln M_{f,t}$ Over Time



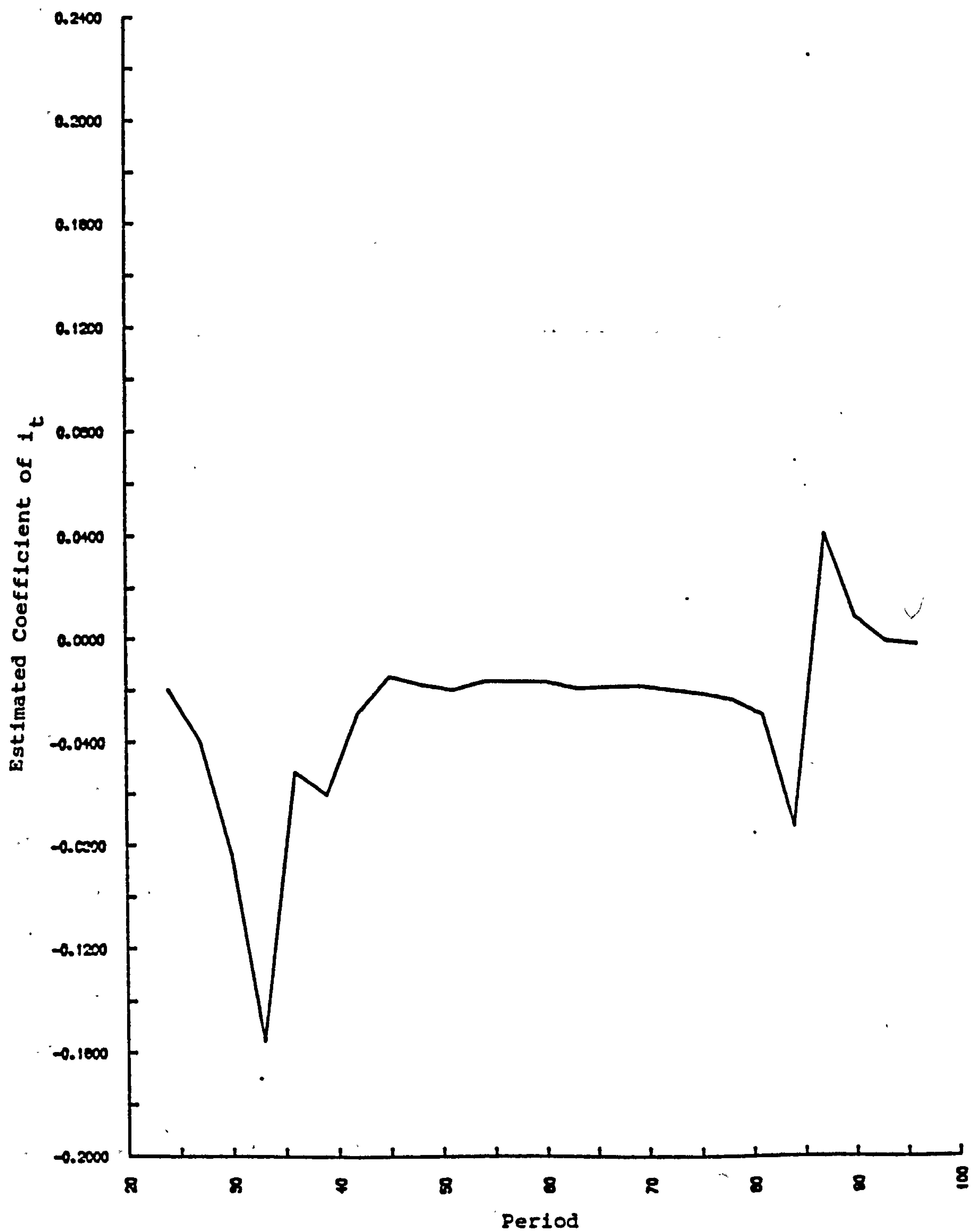
Graph 3M: Variation in the Estimation of the Coefficient of $\ln Y_t$ Over Time



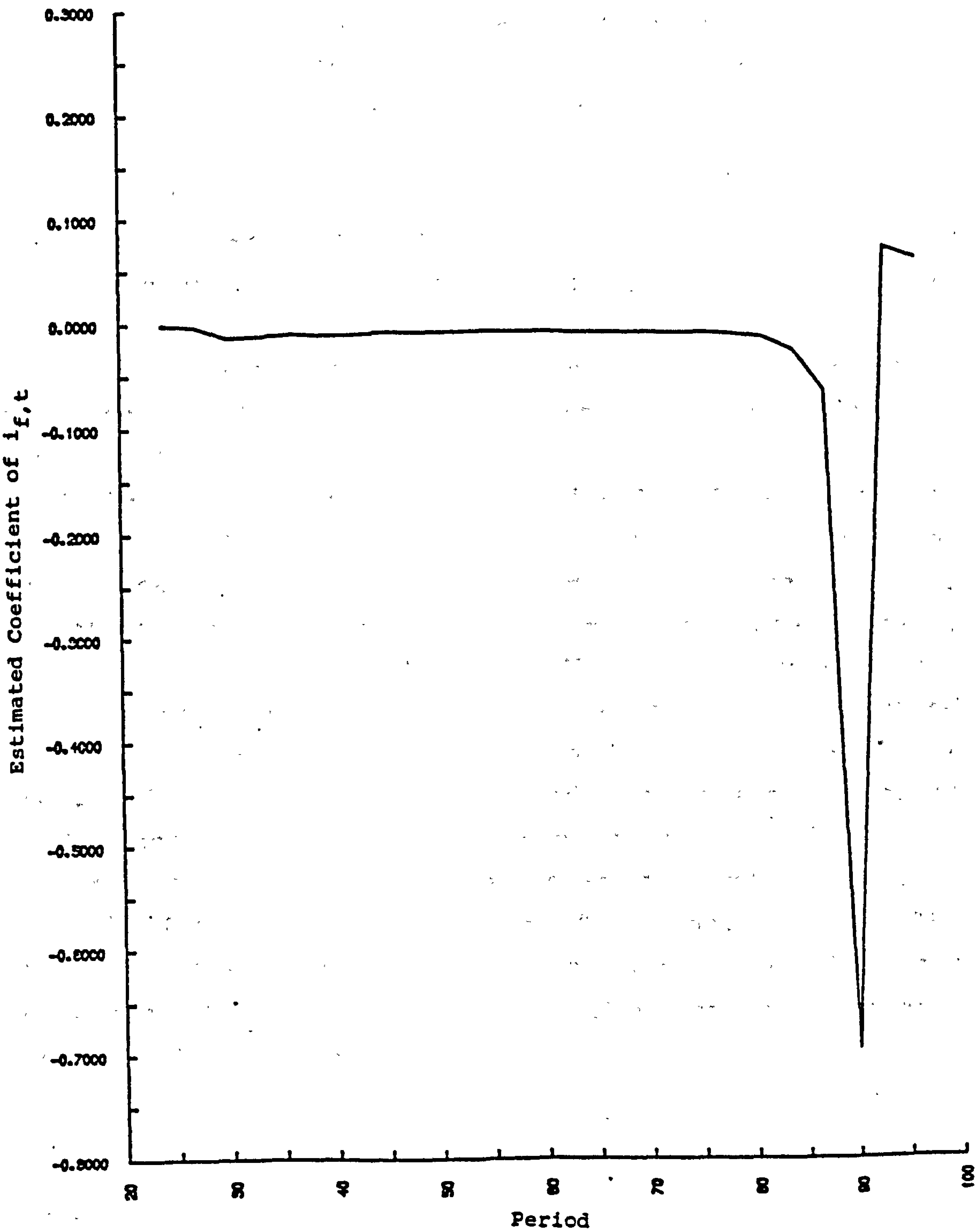
Graph 4M: Variation in the Estimation of the Coefficient of $\ln Y_{f,t}$ Over Time



Graph 5M: Variation in the Estimation of the Coefficient of i_t Over Time



Graph 6M: Variation in the Estimation of the Coefficient of $i_{f,t}$ Over Time



The local F-test was used in an attempt to identify and locate more than one structural break in the model. The equation was estimated using the first 15 periods and the hypothesis that the following three periods could be assumed to be explained by the same structural equations was tested. An affirmative conclusion meant the base estimation was extended to include those three additional observations, and the next three observations were tested to see if they were generated by the base model. This procedure was repeated until the hypothesis that the three additional observations were explained by the estimated equation was rejected, indicating a structural break had been located. The next 15 periods after the structural break were then used for a new base estimation, and the process repeated until a new structural break was located.

Table 2M presents the local F-test values calculated. There is evidence, at the 95% or greater significance level, of structural breaks near observations 39, 69, and 90. The modified local F-test, proposed by Briscoe and Roberts (77) as a stronger test, provides further evidence of the existence of the located structural breaks at the 95% significance level or better. Thus, it may be concluded that there is strong (in Briscoe and Robert's terminology) evidence of structural breaks in the model near periods 39 (March, 1975), 69 (September, 1977), and 90 (June, 1979). The last of these breaks coincides with the Thatcher Goverment's 1979 removal of restrictions on international investments by UK investors.

Table 2M

First Observation of Estimation Period (f)	Last Observation of Estimation Period (L)	Number of Additional Observations Tested for Conformity with First M Observations (n)	Calculated F-Statistic	Calculated Modified F-Statistic	M = 1+L-f	$F_{n,\ m-q}$ (q=5= degrees of freedom) 95% Critical Value	$F_{n,n+m-q}$ 95% Critical Value
1	39	6	3.77	2.62	39	$F_{6,30}$ = 2.42	$F_{6,30}$ = 2.42
40	69	3	8.48	4.55	30	3.03	2.99
70	90	3	6.88	3.38	21	3.34	3.20

The Local F-Statistic is caclulated as: $$F_{n,m-q} = \frac{(Y_{m+n} - Y_m)/n}{Y_m/m-q}$$

where Y is the residual sum of squares.

The Modified Local F-Statistic is calculated as: $$F_{n,m+n-q} = \frac{(Y_{m+n} - Y_m)/n}{Y_{m+n}/m+n-q}$$

E. Investigation of the Sensitivity of the Estimation to the Money Supply Measure Used.

In an attempt to study the seriousness of data problem 4 from section IV. (the inability of monetary theory to designate one money supply measure over all others as appropriate for testing this model) in a more general way than V.C., data for two other money supply measures (M3 and M1, both seasonally adjusted) were used in estimations otherwise identical to the original estimation (equation 3M). In addition to weakness resulting from the misspecification problem, any conclusions from this study are further weakened by the fact that the estimations being compared are not nested in each other or in any more general model.*

Table 3M presents the three estimations over the 98 observation sample period. Aside from subjective judgement as to the comparability of the three estimations, non-nested tests, such as those developed by Davidson and MacKinnon (81), become the only means of comparing such estimations.

*Since M3=sterling M3 + foreign currency holdings = M1 + quasi money, both sterling M3 and M1 can be said to be nested in M3. However, the log form of money supply is being used in regression and since $\ln(M1+QM) \neq (\ln M1) + (\ln QM)$, this nestedness of money supply measures does not result in nestedness of the finally estimated equations.

TABLE 3M

Variable	Coefficients (t-stat) Original data (M=Stg M3)		Coefficients (t-stat) M=M3		Coefficients (t-stat) M=M1	
Const	+13.583	(5.77)	+14.781	(8.38)	-3.680	(3.49)
lnM	-1.004	(5.41)	-1.115	(8.07)	+.672	(6.21)
lnM_f	+.602	(2.87)	+.823	(4.89)	-1.252	(10.23)
lnY	+.133	(.706)	+.269	(1.61)	+.081	(.446)
lnY_f	-.901	(.473)	-1.027	(6.24)	-.811	(4.71)
i	+.003	(.940)	+.004	(1.96)	-.0007	(.030)
i_f	+.032	(11.92)	+.030	(12.99)	+.031	(12.09)
	$\bar{R}^2$ = .914		$\bar{R}^2$ = .933		$\bar{R}^2$ = .920	
	se = .046		se = .040		se = .044	
	DW = .577		DW = .685		DW = .588	
	LLF = 166.66		LLF = 179.46		LLF = 170.35	

Davidson and MacKinnon's J test was used as a formal test of the estimation's sensitivity to the money supply measure used. Execution of the J test involves the following steps. A new variable, g, is generated from each of the estimations above by multiplying the estimated coefficients by the data used in the estimation which generated those coefficients to get that estimation's prediction of the dependent variable over time. This new variable is then included in otherwise identical re-estimations of the other (two) estimations under consideration. Since the new variable represents the alternative hypothesis in this comparison of estimations, a non-zero coefficient on the new variable (tested using a t-test or log likelihood ratio) will lead to rejection of the null hypothesis.

It is important to note that rejection of the null hypothesis does not imply acceptance of the alternative hypothesis. The alternative hypothesis must be tested as a null hypothesis, according to the method above, to be accepted. This fact leads to the unfortunate possibility that, when two hypotheses (estimations) are being compared, both may be accepted or both may be rejected

(in addition, of course, to the possibilities that either one of the hypotheses will be accepted alone.)

Because the present study is not concerned with determining which money supply measure is best for use in this model (indeed, as discussed in section IV , it is unable to make such a determination) the possibility of rejection or acceptance of more than one null hypothesis will imply sensitivity of the estimation to the money supply measure used.

The t-statistics for the coefficients of the alternative hypothesis variables for all possible null hypothesis-alternative hypothesis combinations are presented in table 4M.

TABLE 4M

		H1		
		Stg M3	M3	M1
H_O	Stg M3	X	8.78	3.56
	M3	6.22	X	1.34
	M1	2.29	4.53	X

Critical Values	75%	90%	95%	99%
n=60	.679	1.296	1.671	2.390
n=120	.677	1.289	1.658	2.358

Table 4M contains numerous significant t-statistics meaning that most of the null hypotheses are rejected. It therefore must be concluded that the estimation is sensitive to the money supply measure used.

F. Investigation of the Sensitivity of the Estimation to the Interest Rate Used

The seriousness of data problem 5 from section IV (the inability of theory to designate the appropriate interest rate for testing the model), was tested in much the same manner used in V.E. to test for sensitivity to the money supply measure used. Again, the equations estimated cannot be seen to be nested in each other or any more general model, and so the Davidson and MacKinnon non-nested tests were used in comparing the results.

As possible alternatives to the 3-month sterling interbank (IB) interest rate data used in the original estimations 3-month Paris Eurosterling (ES) rate data and 3-month Tresury Bills (TB) rate data were used for the variable i in estimations otherwise identical to the original estimations. Table 5M presents the three estimations over the 98 observation sample period.

Table 5M

Variable	Coeff's (t-Stat) Original Data (i=Stg Interbank Rate)		Coeff's (t-Stat) i=Paris Eurosterling Rate		Coeff's (t-Stat) i=T-Bill Rate	
Const	+13.583	(5.77)	+10.005	(3.95	+12.813	(5.92)
lnM	-1.004	(5.41)	-.700	(3.46)	-.944	(5.45)
$\ln M_f$	+.602	(2.87)	+.264	(1.15)	+.530	(2.78)
lnY	+.133	(.706)	+.059	(.314)	+.117	(.619)
$\ln Y_f$	-.901	(.473)	-.736	(3.90)	-.855	(4.71)
i	+.003	(.940)	-.003	(1.31)	+.001	(.531)
i_f	+.032	(11.92)	+.033	(12.81)	+.032	(12.09)
	$\bar{R}^2$ = .914		$\bar{R}^2$ = .915		$\bar{R}^2$ = .913	
	se = .046		se = .046		se = .046	
	DW = .577		DW - .506		DW = .559	
	LLF = 166.66		LLF = 167.11		LLF = 166.34	

The alternative hypothesis variables' t-statistics for all possible J-tests comparing the three estimations are presented in Table 6M.

TABLE 6M

H_1

		IB	TB	ES	
H_o	IB	X	1.14	4.10	
	TB	1.38	X	3.02	
	ES	3.98	2.75	X	
Critical Values		75%	90%	95%	99%
n=60		.679	1.296	1.671	2.39
n=120		.677	1.289	1.658	2.36

The presence of significant test statistics provides evidence in favor of rejection of the hypothesis that the choice of interest rate makes no difference to the estimation.

G. Investigation of the Sensitivity of the Estimation to the Use of 5 Country Proxies for the 17 Country MERM Weighted Average M_f and Y_f

The consequences of the simplification involved in data problem 1 in section IV were studied by estimating the model using quarterly data (as mentioned, all of the necessary data is not available for a 17 country estimation using monthly data) with the 17 country MERM weighted average M_f and Y_f, and the 5 country MERM weighted average M_f and Y_f, alternately. Only the counterpart (1972 I to 1979 IV) of the 98 observation data set was estimated since even it involved only 32 observations and so only 25 degrees of freedom. H&T's data were used for the EER, and for M, i, and i_f since all of these are end of period data meaning that the quarterly data could be picked out of the monthly data.

Quarterly UK income data (period average data) were found in IFS and M_f and Y_f were calculated using MERM weights based on 1977 trade flows.

These two quarterly data estimations are presented for comparison in Table 7M.

TABLE 7M

Variable	Coeff's (T-Stat) 17 Country M_f and Y_f		Coeff's (T-Stat) 5 Country M_f and Y_f	
Const	+10.27	(4.86)	+9.483	(4.40)
lnM	-.792	(4.26)	-8.61	(4.45)
$\ln M_f$	+.402	(2.03)	+.455	(2.09)
lnY	+.211	(.523)	+.256	(.619)
$\ln Y_f$	-1.243	(3.20)	-1.123	(3.11)
i	+.006	(1.26)	+.005	(1.07)
i_f	+.031	(6.38)	+.031	(6.28)
	$\bar{R}^2$ = .922, se = .044		$\bar{R}^2$ = .919, se = .045	
	DW = 1.566, LLF = 58.55		DW = 1.503, LLF = 58.03	

Again, the Davidson and MacKinnon J test was used to test the sensitivity of the estimation to the use of the five country proxies. With the 17 country estimation cast as the alternative hypothesis, the relevant t-statistic is 1.07 (for n = 30, the t-statistic critical values are .683 at the 75% significance level and 1.31 at the 90% significance level), while the t-statistic of the coefficient of the alternative hypothesis variable is .498 when the five country estimation is the alternative hypothesis. Thus, in neither case is the null hypothesis rejected at the 90% level. On the basis of this test, there is no evidence that the use of five country proxies for 17 country MERM weighted averages of M_f and Y_f significantly effects the estimation.

H. Investigation of the Sensitivity of the Estimation to Using Trade Flow Based Weights Instead of Capital Flow Based Weights

In an attempt to get an idea of the estimation's sensitivity to the weights used in calculating M_f and Y_f, quarterly data for the five foreign countries' M3's and industrial productions were used to calculate two correlation matrices. Less than perfectly correlated M3s and industrial productions across the countries would mean that using different weights in making up M_f and Y_f would result in different data sets being used in estimation for those two variables. The two correlation matrices are presented in tables 8M and 9M.

TABLE 8M

Correlation Matrix of 5 Industrial Countries'
M3 Money Supplies - Quarterly Data (1972 I - 1979 IV)

	FRA	GER	ITA	JAP	USA
FRA	1.000				
GER	.989	1.00			
ITA	.992	.986	1.00		
JAP	.951	.948	.944	1.00	
USA	.950	.930	.929	.968	1.00

TABLE 9M

Correlation Matrix of 5 Industrial Countries'
Industrial Productions - Quarterly data (1972I-1979IV)

	FRA	GER	ITA	JAP	USA
FRA	1.000				
GER	.905	1.000			
ITA	.946	.884	1.000		
JAP	.875	.913	.898	1.00	
USA	9.20	.928	.880	.904	1.00

The tables indicate that the data for the various countries are less than perfectly correlated in both cases, the discrepancy being greatest in the case of industrial productions.

Next, the similarity of trade flow based and capital flow based weights was studied. If the two sets of weights are closely related, using trade flow based weights may cause no problem. Calculation of MERM trade based weights is a complicated procedure and no attempt was made to calculate a capital flows based counterpart. Instead, US balance of payments data were used (UK data were unavailable) to calculate simple export, import, and capital flow based weights, for three different dates. Tables 10M, 11M, and 12M present these various weights for comparison.

These three tables seem to point to the conclusion that there is a difference between trade flow based weights and capital flow based weights--at least in the case of the US. The data reported also indicate the added complexities would be involved in using capital flow based weights--both because they appear to be more volatile, and because it is not uncommon that a meaningful weight does not exist for a given year.

There is evidence, then, that if capital flow based weights were used in place of trade flow based weights in calculating M_f and Y_f, the estimation might be affected--though no significance level can be placed on this effect.

TABLE 10M

US - UK data

	1972 Millions of Dollars	1972 Weight (% of US Total)	1975 Million Dollars	1975 Weight	1978 Million Dollars	1978 Weight
Exports	4610	6.0	7710	5.2	13301	6.0
Imports	-5574	7.1	-7443	5.7	-12643	5.5
Δ For. Assets	-160	1.6	-3388	10.9	-7896	12.8
Δ For. Liab.	-1095	Undefined	-208	Undefined	735	1.2

TABLE 11M

US - Can. data

	1972 Millions of Dollars	1972 Weight (% of US Total)	1975 Million Dollars	1975 Weight	1978 Million Dollars	1978 Weight
Exports	16398	22.3	29606	20.0	42007	19.0
Imports	-16696	21.4	-24743	18.9	-37210	16.2
Δ For. Assets	-1726	17.1	-4347	14.0	-8800	14.3
Δ For. Liab.	756	3.6	-703	Undefined	2859	4.5

TABLE 12M

US - Japan data

	1972		1975		1978	
	Millions of Dollars	Weight (% of US Total)	Million Dollars	Weight	Million Dollars	Weight
Exports	6700	9.1	12726	8.6	18259	8.3
Imports	-11441	14.7	-14055	10.7	-29724	13.0
ΔFor. Assets	-207	2.0	1595	Undefined	-4358	7.1
ΔFor. Liab.	5140	24.7	-548	Undefined	13749	21.6

VI. Conclusions and Suggestions They Imply for Subsequent Research

The most important result of this empirical study of the simple monetary model of exchange rate determination is that the model shows evidence of dynamic misspecification. This conclusion suggests that Hacche and Townend were incorrect to assume that the autocorrelation exhibited by their OLS estimation of the model was simply evidence that autocorrelation exists in the true model. Furthermore, the presence of dynamic misspecification is grounds for rejection of the simple monetary model and the development of a dynamically more complex model which does not show signs of misspecification. The latter is pursued in the following chapters, where the effects of two steps in sophistication, first to a Dornbusch type model and then to a simple stock-flow model, are analysed. For now, however, this evidence of dynamic misspecification severely weakens the conclusiveness of the other results of this chapter -- no strong conclusions may be drawn from a misspecified model.

Tentatively, then, the other conclusions of this chapter are as follows:

1) There is evidence of three structural breaks in the model over the period estimated. The breaks have been roughly located as around March, 1975, September, 1977, and June, 1979.
2) There is evidence that the choice of money supply measure used makes a significant difference in the statistics estimated.
3) There is evidence that the choice of interest rate used makes a significant difference in the statistics estimated.

4) There is no evidence that using 5 country averages for M_f and Y_f instead of their 17 country counterparts, makes a significant difference in the statistics estimated.

5) There is some evidence (though no formal testing was done) that using capital flow based weights in calculating M_f and Y_f would result in different estimates of statistics calculated.

These latter five conclusions may be studied more rigorously and, it is hoped, more conclusively, when and if a model exhibiting no signs of misspecification is identified.

Appendix

(2aM)

$$\ln EER = \underset{(.775)}{-1.782} + \underset{(.254)}{.050}\ln M + \underset{(.677)}{.221}\ln M_f - \underset{(.266)}{.021}\ln Y$$

$$+ \underset{(.895)}{.174}\ln Y_f - \underset{(2.92)}{.005}i + \underset{(.553)}{.001}i_f + \underset{(48.5)}{.980}u_{t-1}$$

$\bar{R}^2$=.988, se=.017, DW=1.32, LLF=262.11, obs.=98

(4aM)

$$\ln EER_t = \underset{(.765)}{.842} + \underset{(23.4)}{.977}\ln EER_{t-1} - \underset{(.686)}{.136}\ln M_t$$

$$+ \underset{(.096)}{.020}\ln M_{t-1} + \underset{(.042)}{.020}\ln M_{f,t} + \underset{(.195)}{.091}\ln M_{f,t-1}$$

$$+ \underset{(.405)}{.034}\ln Y_t + \underset{(.722)}{.061}\ln Y_{t-1} + \underset{(1.01)}{.203}\ln Y_{f,t}$$

$$- \underset{(1.07)}{.225}\ln Y_{f,t-1} - \underset{(3.08)}{.005}i_t + \underset{(3.50)}{.006}i_{t-1}$$

$$+ \underset{(.085)}{.0002}i_{f,t} + \underset{(.624)}{.001}i_{f,t-1}$$

$\bar{R}^2$=.989, se=.016, DW=1.574, LLF=270.75, obs.=97

(4bM)

$$\ln EER_t = \underset{(1.32)}{-2.301} + \underset{(6.14)}{.709}\ln EER_{t-1} - \underset{(.184)}{.034}\ln M_t$$

$$+ \underset{(1.17)}{.259}\ln M_{t-1} - \underset{(1.43)}{.862}\ln M_{f,t} + \underset{(.636)}{.385}\ln M_{f,t-1}$$

$$+ \underset{(.099)}{.009}\ln Y_t - \underset{(.075)}{.007}\ln Y_{t-1} - \underset{(.171)}{.033}\ln Y_{f,t}$$

$$- \underset{(.009)}{.002}\ln Y_{f,t-1} - \underset{(5.01)}{.010}i_t + \underset{(3.38)}{.007}i_{t-1}$$

$$+ \underset{(1.49)}{.004}i_{f,t} - \underset{(.499)}{.001}i_{f,t-1}$$

$\bar{R}^2$=.992, se=.014, DW=1.922, LLF=206.06, obs.=69

The Dornbusch Model

I. Introduction

In this chapter I develop and test an empirical model based on the Dornbusch (76 JPE) model. This model represents a step forward in dynamic sophistication relative to the monetary model in that goods markets are no longer assumed to clear instantaneously.

The model is developed in section II. The realism of the expectations formation equation is discussed in section III paving the way for empirical work on this topic in section V. The data used in estimation are discussed in section IV, and section V presents the empirical work on the model.

II. Development of an Empirical Model Based on the Dornbusch Model*

Relaxation of three of its restricting assumptions transforms the simple monetary model developed in the last chapter into the Dornbusch model of exchange rate dynamics.

First, prices are assumed to be sticky in the short run, so that goods markets are not necessarily in equilibrium. Second, purchasing power parity is reduced to a long run phenomenon. Together, these first two modifications mean that new relationships must be defined to describe the status of the good markets.

To that end, the log of a countries' inflation rate, $\Delta \ln P$, is assumed to be a linear function of the log of the ratio of the demand for a countries' goods, D, to the supply of that countries' goods, Y,

(6) $\Delta \ln P = \Phi \ln(D/Y)$.

With demand assumed to be a function of relative prices, domestic income level, and the domestic interest rate,

(7) $\ln D = u + a\ln Y - bi + c\ln(P_f/PS)$,

equation 6 becomes:

(8) $\Delta \ln P = \Phi[u + (a-1)\ln Y - bi + c\ln(P_f/PS)]$.

The third restricting assumption of the monetary model to be relaxed is the exogeneity of expected changes in the exchange rate, $E(\hat{S})$. In the Dornbusch model expectations are endogenized (thus domestic interest

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*The model developed here is a synthesis of the Dornbusch (76 JPE) based empirical models developed by Driskill (81) (amended as suggested by Backus (84) and footnoted below) and H&T. The present model is more general than the Driskill model, which worked with most variables as log ratios of domestic to foreign variables and more faithful to Dornbusch than H&T's development which stops at equation 14 below.

rates become endogenous) by assuming that they are formed as follows:

(9) $E(\hat{S}) = \psi(\ln\bar{S} - \ln S)$,

where $\bar{S}$ is the expected long run equilibrium exchange rate and ψ is a linear function.

Assumptions of money market equilibrium,

(2) $\ln M\ (=\ln M^d) = \ln\alpha + \beta\ln P + \gamma\ln Y - \delta i$

and perfect capital mobility,

(5) $i_f - i = E(\hat{S})$

remain intact from the monetary model.

Combining equations 2, 5 and 9 and solving for lnS gives:

(10) $\ln S = \ln\bar{S} + \frac{\ln\alpha}{\delta\psi} + \frac{\beta}{\delta\psi}\ln P + \frac{\gamma}{\delta\psi}\ln Y - \frac{1}{\psi}i_f - \frac{1}{\delta\psi}\ln M.$

Imposing the steady state ($\Delta\ln P=0$, $P=\bar{P}$, $S=\bar{S}$, and $i=i_f$) on equations 10 and 8, respectively, results in the steady state equations:

(11) $\ln\bar{P} = -\frac{1}{\beta}\ln\alpha + \frac{1}{\beta}\ln M - \frac{\gamma}{\beta}\ln Y + \frac{\delta}{\beta}i_f$

(12) $\ln\bar{S} = \ln(P_f/\bar{P}) + \frac{1}{c}[u + (a-1)\ln Y - bi_f]$

which combine to give the expression for the long run equilibrium exchange rate.

(13) $$\ln\bar{S} = \frac{u}{c} + \frac{\ln\alpha}{\beta} + \ln P_f - \frac{1}{\beta}\ln M + \left[\frac{a-1}{c} + \frac{\gamma}{\beta}\right]\ln Y - \left[\frac{b}{c} + \frac{\delta}{\beta}\right]i_f.$$

Inherent in the use of this expression for calculation of the expected long run equilibrium exchange rate is the implied assumption that the exogenous variables in the expression ($\ln P_f$, $\ln M$, $\ln Y$, and i_f) are not expected to change--traders are assumed to expect that the long run equilibrium values of these exogenous variables are equal to the present values of these variables.

Substituting equation 13 into equation 10 gives the international asset market equilibrium equation,

$$(14)\qquad \ln S = \left[\frac{u}{c} + \frac{\ln\alpha}{\beta} + \frac{\ln\alpha}{\delta\psi}\right] + \ln P_f + \frac{\beta}{\delta\psi}\ln P - \left[\frac{1}{\beta} + \frac{1}{\delta\psi}\right]\ln M + \left[\frac{\gamma}{\beta} + \frac{a-1}{c} + \frac{\gamma}{\delta\psi}\right]\ln Y - \left[\frac{\delta}{\beta} + \frac{b}{c} + \frac{1}{\psi}\right]i_f.$$

When developing the Dornbusch model for theoretical use the above equations may be manipulated to give a goods market equilibrium equation. Since such an equation holds only in the long run, it is of little use in empirical work on the model. Still, the effect of partial adjustment of the price level towards the long run goods market equilibrium level may be included in the short run equation to be estimated. Equations 14 and 2 are used to remove lnS and i, respectively, from equation 8 to obtain an equation for $\ln P_{t+1}$ in terms of exogenous variables*,

$$(15)\qquad \ln P_{t+1} = \left[\frac{-c\ln\alpha}{\beta} - \frac{c\ln\alpha}{\delta\psi} - \frac{b\ln\alpha}{\delta}\right] + \left[1 - \varphi c - \frac{\varphi c}{\delta\psi} - \frac{\varphi b\beta}{\delta}\right]\ln P_t + \varphi\left[\frac{c}{\beta} + \frac{c}{\delta\psi} + \frac{b}{\delta}\right]\ln M_t - \gamma\varphi\left[\frac{b}{\delta} + \frac{c}{\beta} + \frac{c}{\delta\psi}\right]\ln Y_t + \varphi c\left[\frac{\delta}{\beta} + \frac{b}{c} + \frac{1}{\psi}\right]i_{f,t}.$$

---

*Backus has pointed out that lagging an equation such as 8 (the method followed by Driskill), which includes endogenous variables, introduces first order moving average character into the error term of the estimated equation.

Equation 15 is then lagged and substituted back into equation 14 to give an expression which reflects both the equilibrium status of the money markets and the (possibly disequilibrium) status of the goods market,

$$
\begin{aligned}
(16)\qquad \ln S_t = {} & k + \ln P_{f,t} + \frac{\beta}{\delta\psi}\left[1 - \varphi c - \frac{\varphi c}{\delta\psi} - \frac{\varphi b\beta}{\delta}\right]\ln P_{t-1} \\
& - \left[\frac{1}{\beta} + \frac{1}{\delta\psi}\right]\ln M_t + \frac{c\varphi\beta}{\delta\psi}\left[\frac{1}{\beta} + \frac{1}{\delta\psi} + \frac{b}{c\delta}\right]\ln M_{t-1} \\
& + \left[\frac{\gamma}{\beta} + \frac{a-1}{c} + \frac{\gamma}{\delta\psi}\right]\ln Y_t - \frac{\beta\gamma\varphi}{\delta\psi}\left[\frac{b}{\delta} + \frac{c}{\beta} + \frac{c}{\delta\psi}\right]\ln Y_{t-1} \\
& - \left[\frac{\delta}{\beta} + \frac{b}{c} + \frac{1}{\psi}\right]i_{f,t} + \frac{\varphi c\beta}{\delta\psi}\left[\frac{\delta}{\beta} + \frac{b}{c} + \frac{1}{\psi}\right]i_{f,t-1}.
\end{aligned}
$$

If, as is usually assumed, $\beta=1$, then the coefficients of $\ln P_{t-1}$, $\ln M_t$, and $\ln M_{t-1}$ will sum to unity. Other predictions relative to estimation of this model are a coefficient of unity for $\ln P_{f,t}$, a negative coefficient (of magnitude greater than one if $\beta=1$--the famous overshooting prediction of the Dornbusch model) of $\ln M_t$, positive coefficients for $\ln M_{t-1}$ and $i_{f,t-1}$, and negative coefficients for $\ln Y_{t-1}$ and $i_{f,t}$.

III. A Note on the Expectation Formation Equation.

Although equation 9 might more accurately be referred to as the expectation formation equation of this model, it is the assumed mechanism for arriving at $\ln\bar{S}$ that really defines expectations.

As mentioned in section I, the use of an equation such as 13 in defining lnS* implies that it is expected that the explanatory variables are presently at their long run equilibrium values. In a stochastic model, justification for this assumption comes from the assumption that each of the independent variables follows a random walk which simply means that each explanatory variable, X, is best defined by the equation

(A) $$X_t = X_{t-1} + u_t$$

where u_t is an uncorrelated white noise error term. Starting with equation A, it can be shown that the expected value of X at any time in the future (the long run steady state, for instance) is simply the present value of X

(B) $$X_{t+n} = X_t + u_{t+n}$$

although the variance of u increases with n.

The random walk assumption (and so, the appropriateness of use of an equation such as 13 for lnS) has been tested by Driskill (81,p.364). Unfortunately, he tested the hypothesis that money supply follows a random walk only in that hypothesis' weakest form--that represented by equation A. Unless traders believe that the international economy will arrive at the long run steady state in period t+1, they will probably require

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*H&T use an equation identical to 13, but the $\beta = 1$, while Driskill assumes that the long run exchange rate depends only on the relative money supply.

more evidence than that afforded by Driskill's test that X (money supply in Driskill's case) follows a random walk before accepting an equation such as 13 in forming expectations about the long run steady state exchange rate.

The random walk hypothesis is tested more rigourously (in the form represented by B. for various n) in section V.D.

IV. Data

The data obtained from Townend contained monthly CPI and export prices data (their source being IFS) and so equation 16 was estimated on a monthly basis using the same data, as necessary, used in the original estimations of the monetary model (estimations 1-3M) plus H&T's CPI data for P and the MERM weighted average of five countries' CPI's for P_f. All econometrics on the Dornbusch model were done using the full 98 observation sample period (January, 1972 to February, 1980)--the 70 observation cutoff being considered an unnecessary artifact of H&T's original estimation of the monetary model. As the Dornbusch model formulated in section II includes lagged variables, estimations were made with 97 sample periods.

All of the potential sources of data problems listed in section IV of the monetary model chapter are relevant to some degree in the estimation of the Dornbusch model. In addition, the question of which measure of price level is most appropriate becomes relevant since the price level is one of the model's explanatory variables. Artus (1978), has enumerated the problems in choosing the appropriate measure of price level for work on PPP theory. The choice is only complicated by the fact that the present model requires a hybrid of the "internationally oriented" price level appropriate for work on PPP theory, and the "domestically oriented" price level appropriate when dealing with domestic money and goods markets (non-traded goods, for instance, being relevant in the latter, but not the former case).

Of the problems investigated in the monetary model chapter only the sensitivity of the estimation to the money supply measure used was reinvestigated here.

V. Empirical Work on the Dornbusch Model.

A. Estimation of the Dornbusch Model and Comparison to the Simple Monetary Model

Table 1D presents the result of the OLS estimation of equation 16 using H&T's monthly data as indicated in section IV.

TABLE 1D

Variable	Estimated Coeff	(t-stat)	Theoretical Predictions About Coeff
Constant	5.123	(5.11)	None
$\ln M_t$	0.303	(.578)	< -1
$\ln M_{t-1}$	-1.471	(2.80)	> 0
$\ln P_{f,t}$	2.633	(5.35)	$= 1$
$\ln P_{t-1}$	-1.032	(4.73)	None
$\ln Y_t$	-0.185	(.848)	None
$\ln Y_{t-1}$	0.026	(.119)	< 0
$i_{f,t}$	0.020	(3.65)	< 0
$i_{f,t-1}$	-0.0008	(.126)	> 0

$\bar{R}^2$=.917, se =.044

DW=.359, LLF = 169.35

Perhaps most striking of the results is the Durbin-Watson statistic of .359 which provides strong evidence of autocorrelation (the d_L for k=6, n=95 is 1.56 at the 95% significance level). The model must be tested further for evidence of dynamic misspecification. Although statistics estimated in this regression may be biased owing to the possibility of misspecification, it is interesting to note that the coefficients estimated do not agree well with theory. Of the three variables whose coefficients are both statistically significant (for n=60, t-statistic critical values are: 90%=1.296, 95%=1.671, and 99%=2.390; for n=120 c.v.'s are: 90%=1.289, 95%=1.658, and 99%=2.358) and theoretically predictable, the sign and the magnitude of the coefficient of $\ln M_{t-1}$, the sign of the coefficent of i_f, and the magnitude of the coefficient of $\ln P_f$ are all inconsistent with theory.

The Davidson and MacKinnon J-test may be used to compare this formulation of the Dornbusch model with the monetary model estimated in the last chapter. In this application it would be hoped that the J-test would indicate one of the two models as preferable to the other --here the possibilities of double acceptance and double rejection discussed in section IV.E. have the potential of reducing the usefulness of the test. It is possible that a clear-cut preference for one of the models may not be established.

In fact, the t-statistics for the coefficients of the alternative hypothesis variables of 4.28 when the monetary model is cast as the null hypothesis and 3.12 when the Dornbusch model is cast as the null hypothesis indicate that each model is rejected by the other (critical values given above). The only conclusion that may be drawn from this result is that there is evidence that neither the monetary nor the Dornbusch model is the "true" model.

B. Investigation of the Possibility of Dynamic Misspecification

Showing signs of autocorrelation, as evidenced by the very low Durbin-Watson statistic, the Dornbusch model was tested for evidence of misspecification according to the procedure outlined by Hendry and Mizon and used in sections V.B. and V.C. of the monetary model chapter. The log likelihood ratio comparing the unrestricted first order lagged version of the model to the estimation using the Cochrane-Orcutt autoregressive technique was 17.16. When compared to the Chi squared critical values for n=6 of 12.6 at the 95% level and 16.8 at the 99% level, it must be concluded that there is evidence that this model is dynamically misspecified.

C. Investigation of the Sensitivity of the Conclusion of Misspecification to the Data Used

As in section V.C. of the monetary model chapter, the common factor test of dynamic misspecification was repeated using different data sets to get a feel for the sensitivity of the test to the data used. This time two retests of the common factor hypothesis were done using M1 and M3 in place of sterling M3 for domestic money supply and two retests were done using export prices and unit labor costs in place of the consumer price index for the domestic price level.

In the two retests using different monetary data, the log likelihood ratios comparing the unrestricted first order lagged estimation of the model to the Cochrane-Orcutt autoregressive estimation were 23.96 when M1 was used in estimation and 28.56 when M3 was used. When compared to the same chi squared critical values that were relevant in section V.B. of this chapter, these retest values point to the conclusion that the model is misspecified.

The retests using different price data also support the conclusion that this version of the Dornbusch model is dynamically misspecified. The log likelihood ratios of 27.50 when export prices were used and 33.70 when unit labor costs were used, again measured against the chi squared critical values of 12.6 at the 95% level and 16.8 at the 99% level, are clearly significant at any reasonable level.

All retests of the common factor hypothesis resulted in support for the conclusion of misspecification. Yet the data set used did have considerable impact on the magnitude of the LLR value obtained. Thus it might be argued that there is some set of data which might be seen as appropriate for use in testing this model and which would not result in the conclusion that the model is dynamically misspecified.

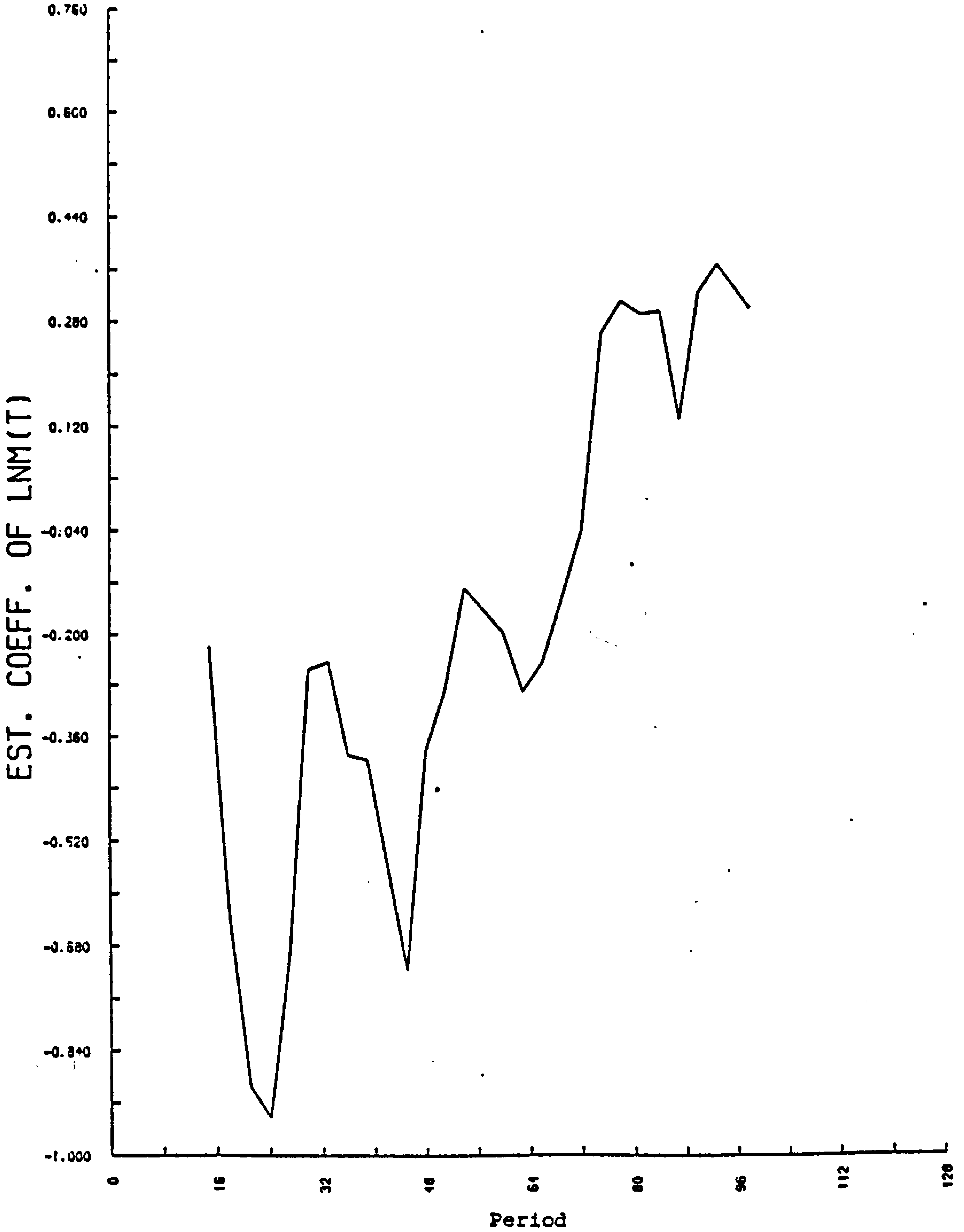
D. Investigation of the Possibility of Structural Breaks

The possibility of structural breaks in the equation reported in section V.A. was studied using the same methods employed in section V.D. of the monetary model chapter.

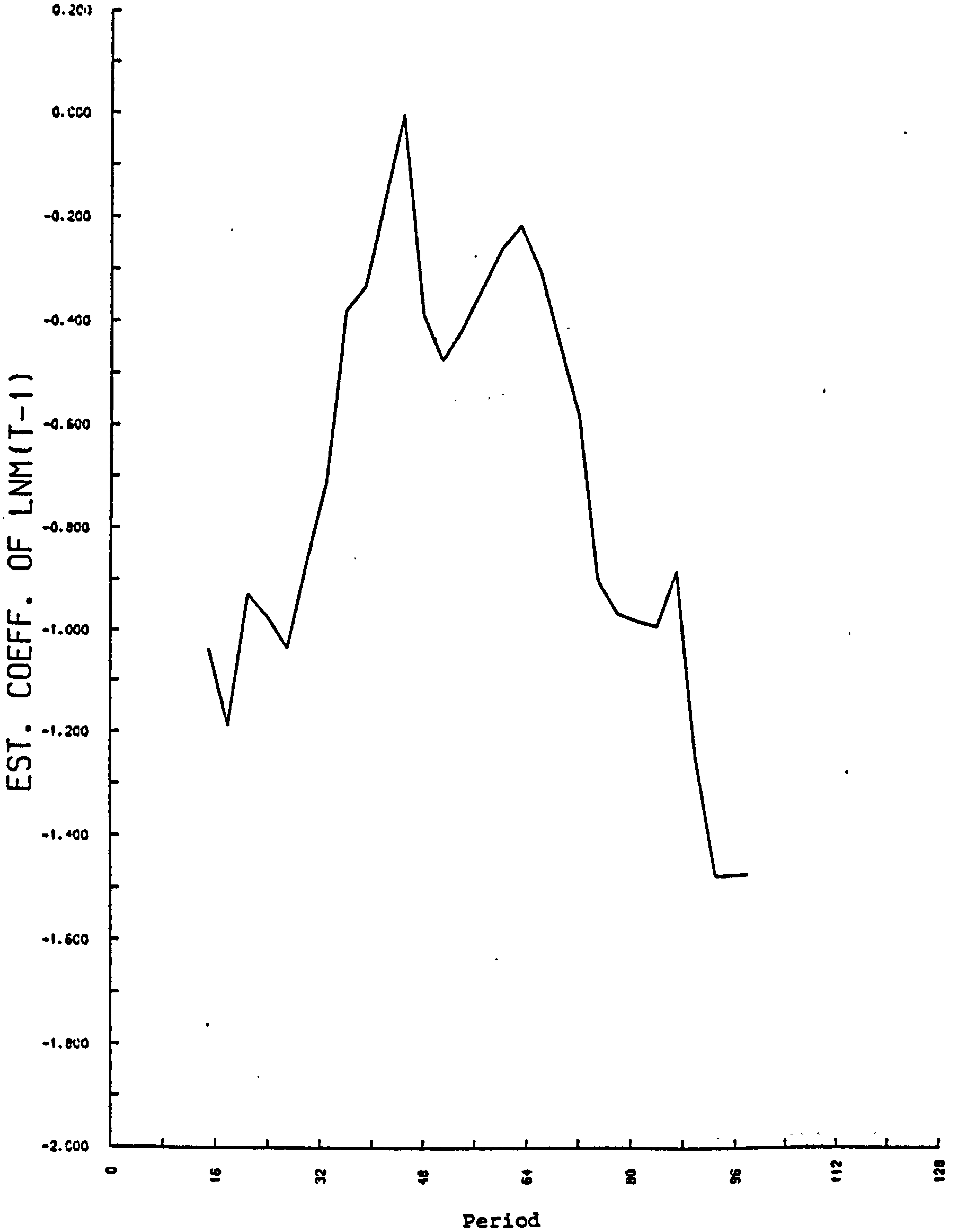
First, graphical methods were used to qualitatively test the constancy of the coefficients estimated over time. Unfortunately, the complexity of the coefficients in the reduced form equation (16) in terms of coefficients from the structural equations meant that structural coefficients could not be calculated from the reduced form coefficients estimated. Consequently, it is theoretically possible that simultaneous offsetting changes in two or more structural coefficients could occur resulting in no observable change in one or more of the reduced form coefficients. Thus constancy of the reduced form coefficients over time does not necessarily mean constancy of the structural coefficients over time.

Graphs 1D-8D provide evidence of considerable variation in the reduced form coefficients estimated over time. Considering that each estimation was cumulative (the first estimation involved the second through the fifteenth observations, the second estimation involved the second through the eighteenth observations, and so on until the last estimation--that reported in section V.A. --which included the second through the 98th

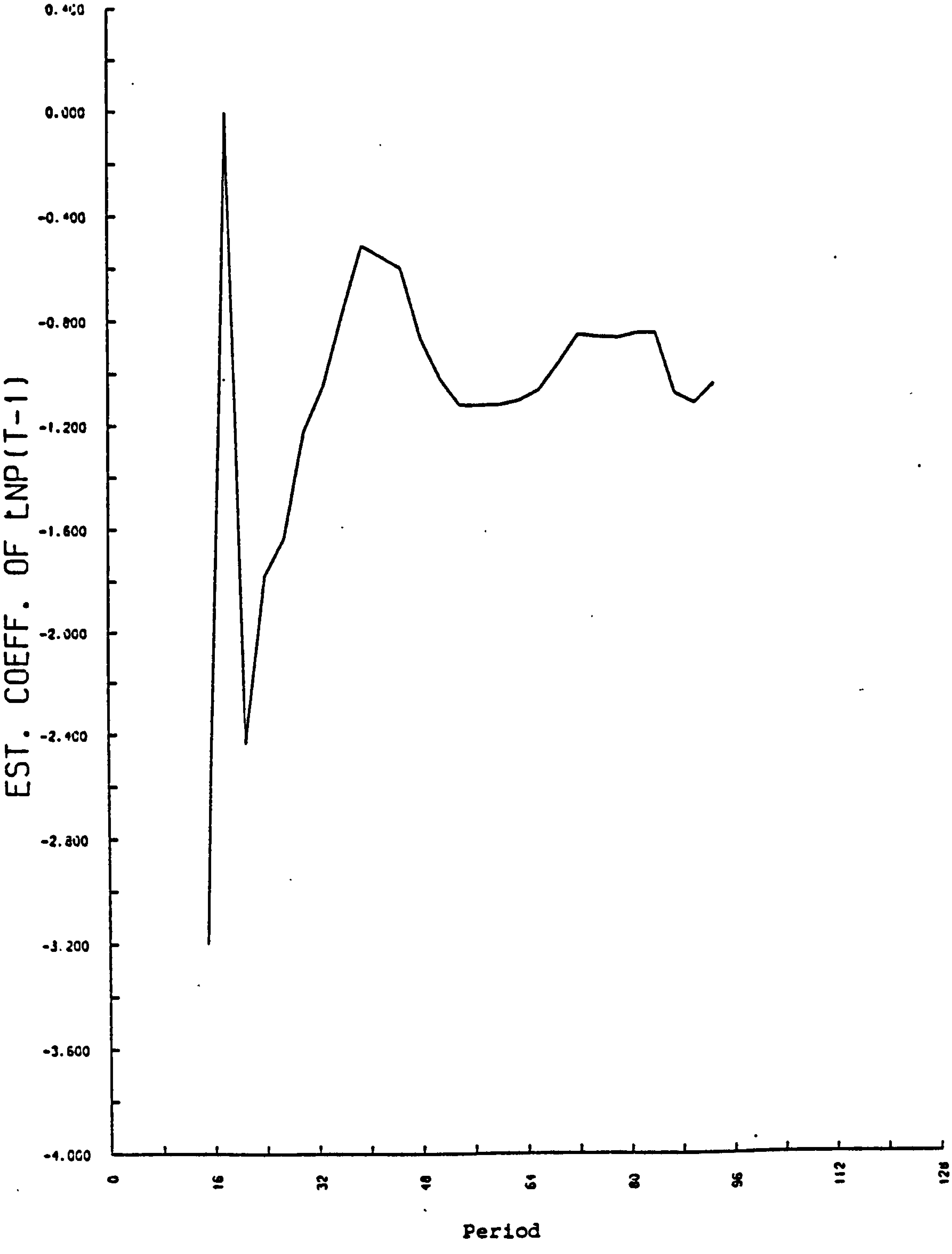
Graph 1D: Variation in the Estimation of the Coefficient of $\ln M_t$ Over Time



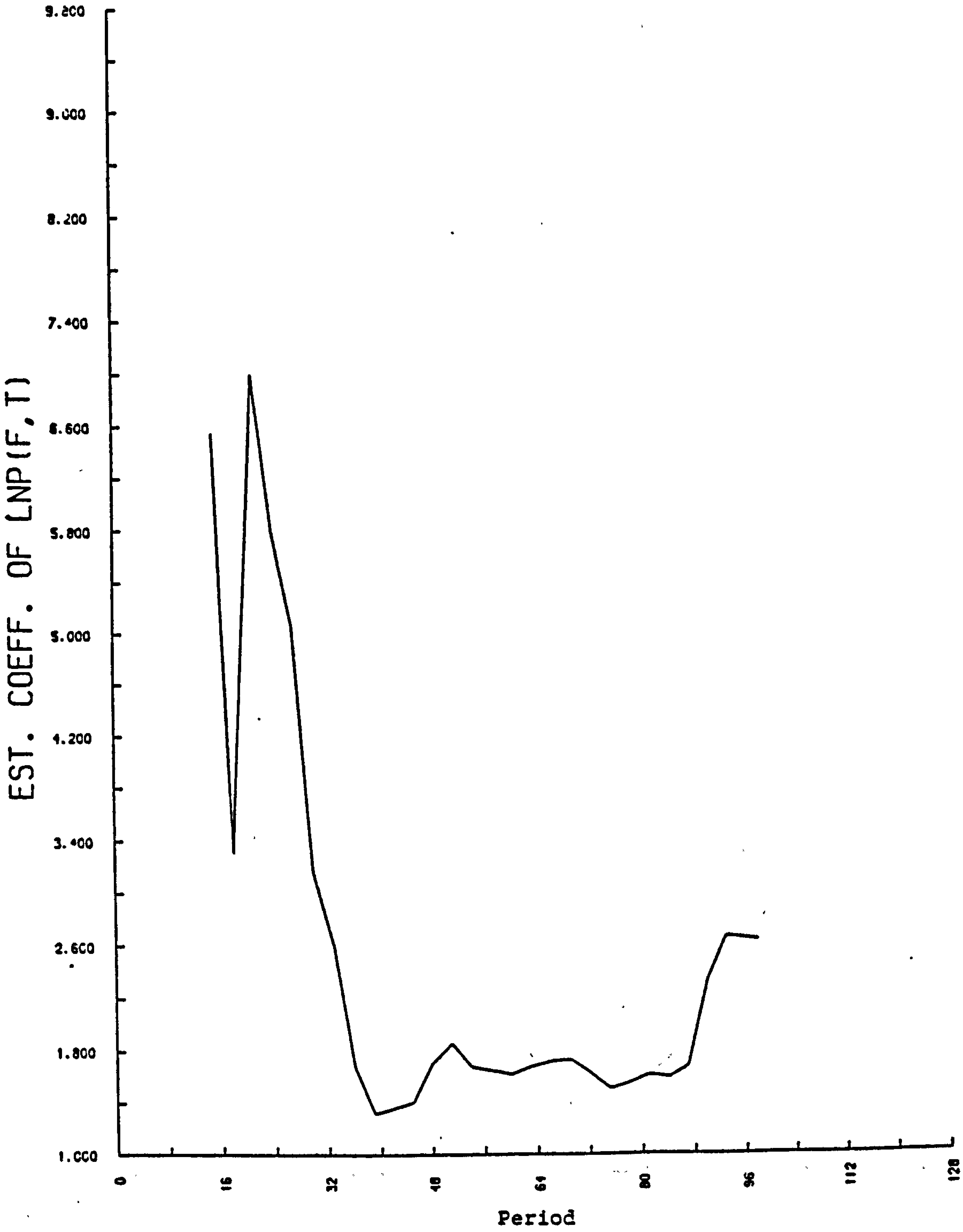
Graph 2D: Variation in the Estimation of the Coefficient of $\ln M_{t-1}$ Over Time



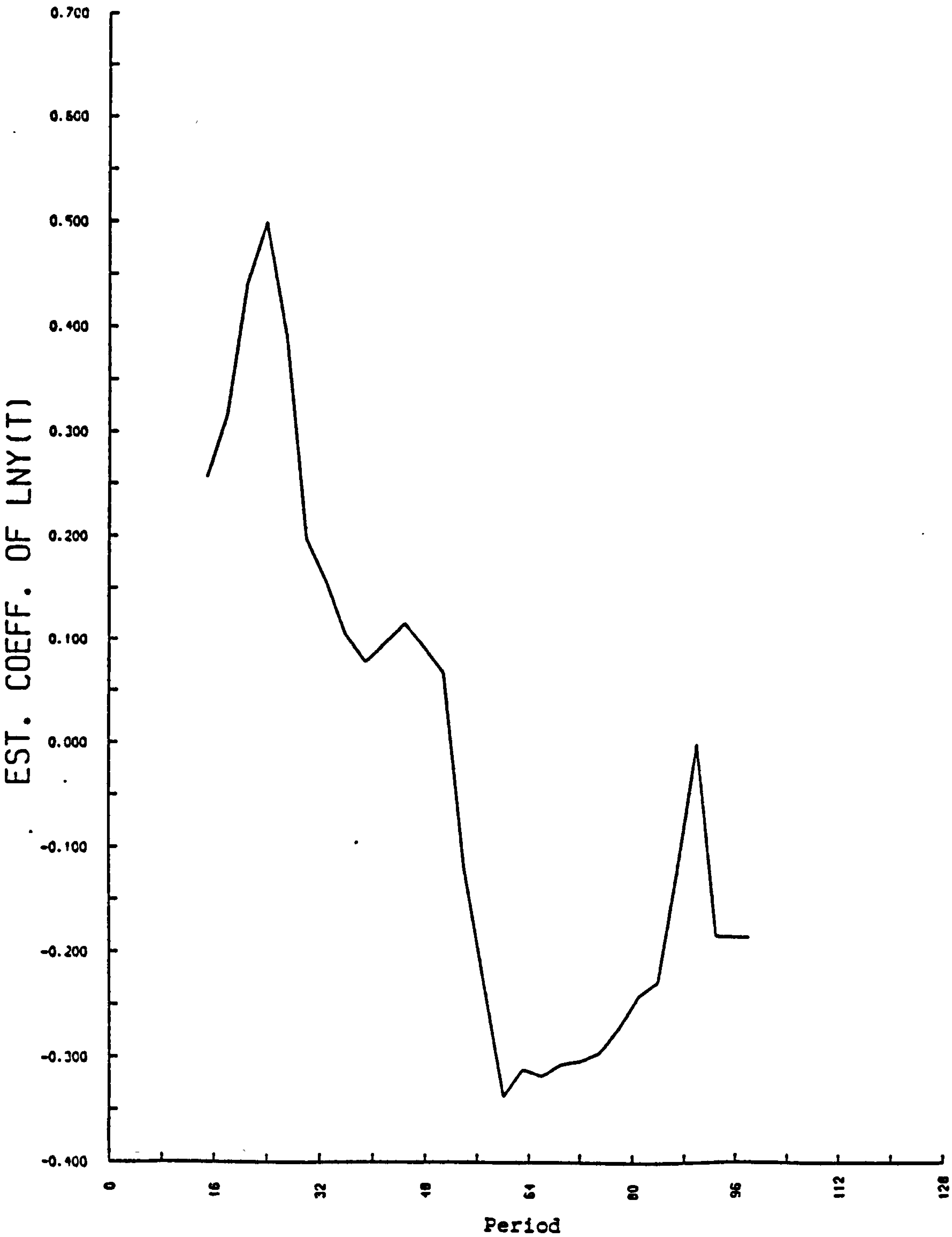
Graph 3D: Variation in the Estimation of the Coefficient of $\ln P_{t-1}$ Over Time



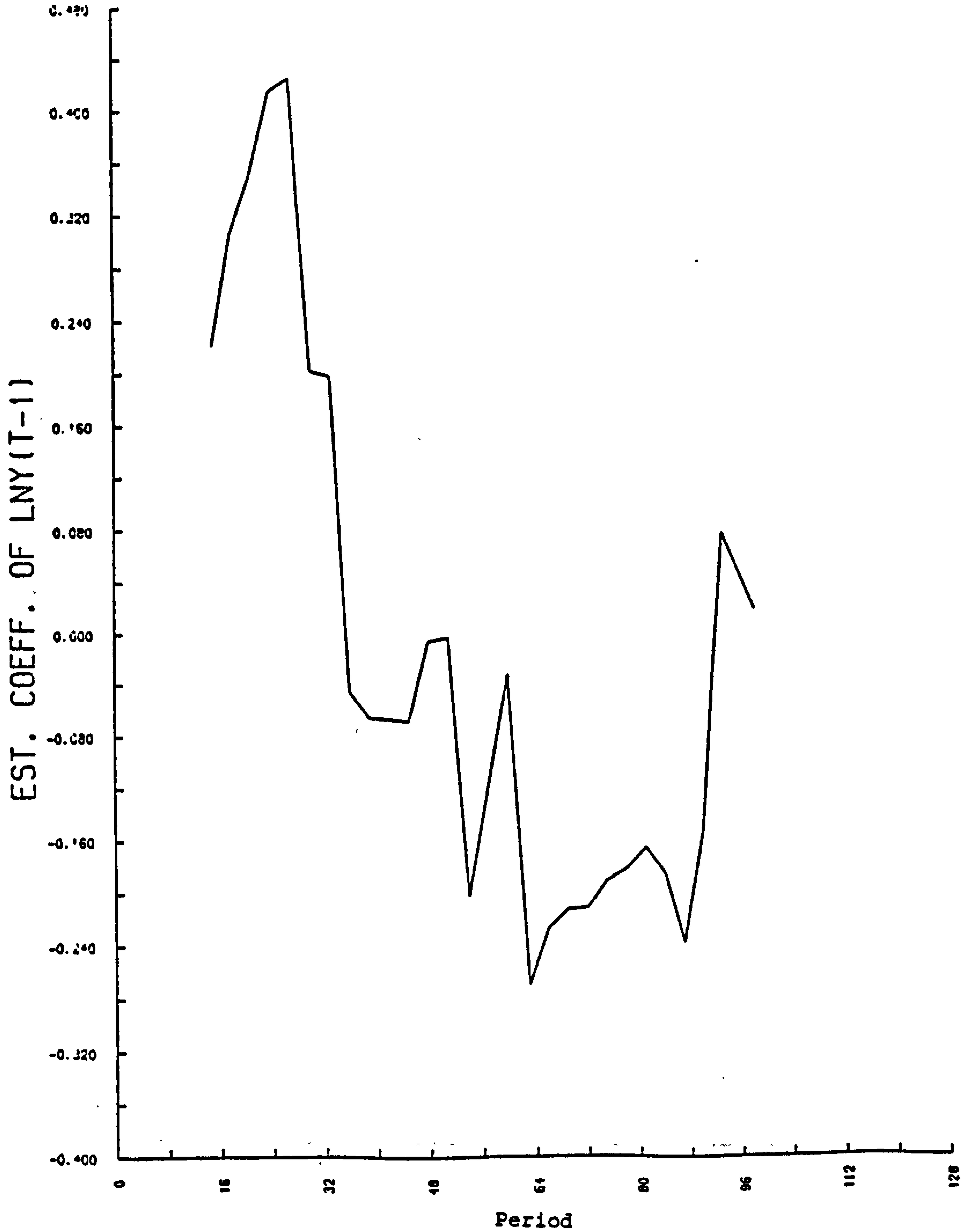
Graph 4D: Variation in the Estimation of the Coefficient of $\ln P_{f,t}$ Over Time



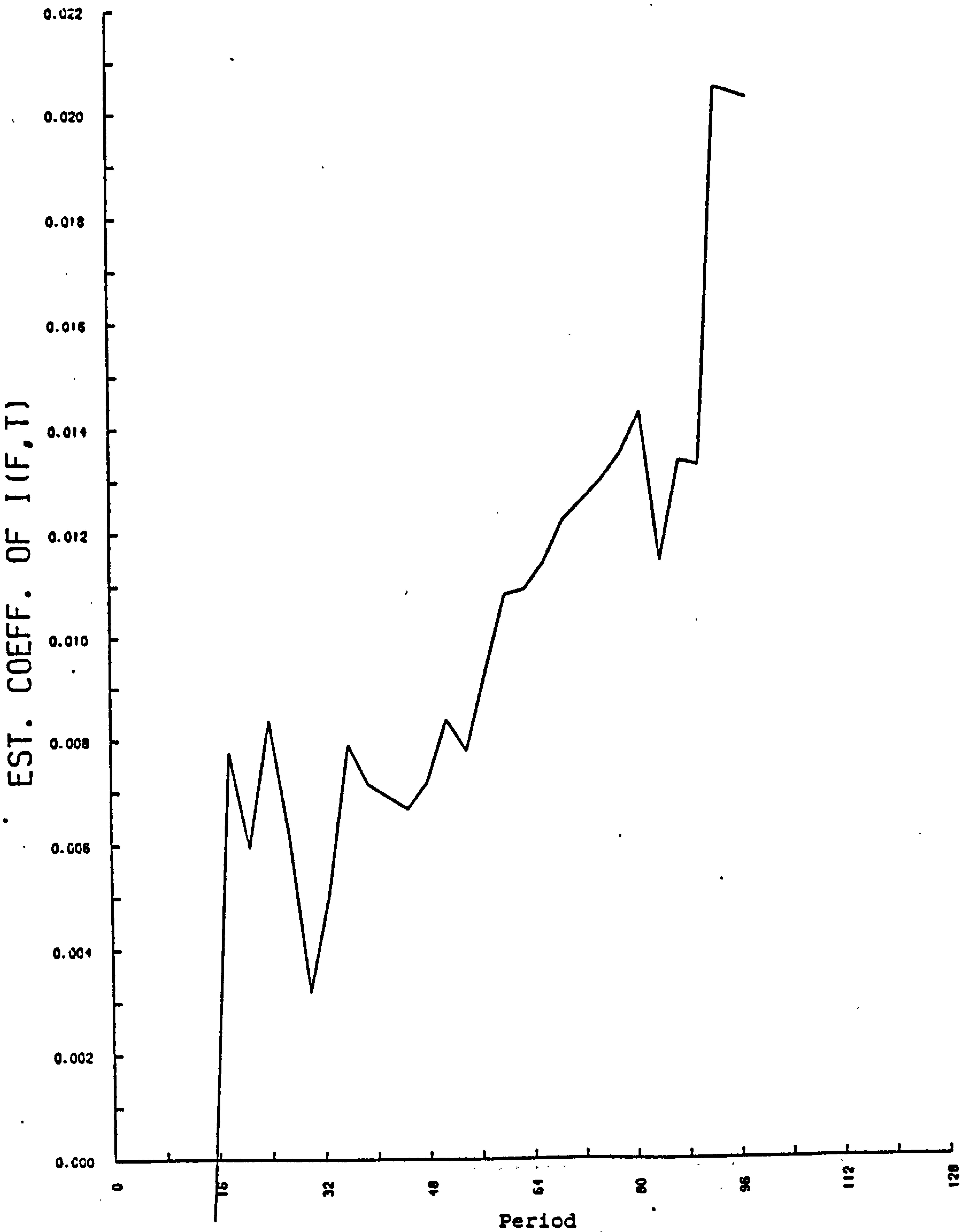
Graph 5D: Variation in the Estimation of the Coefficient of $\ln Y_t$ Over Time



Graph 6D: Variation in the Estimation of the Coefficient of $\ln Y_{t-1}$ Over Time



Graph 7D: Variation in the Estimation of the Coefficient of $i_{f,t}$ Over Time



Graph 8D: Variation in the Estimation of the Coefficient of $i_{f,t-1}$ Over Time

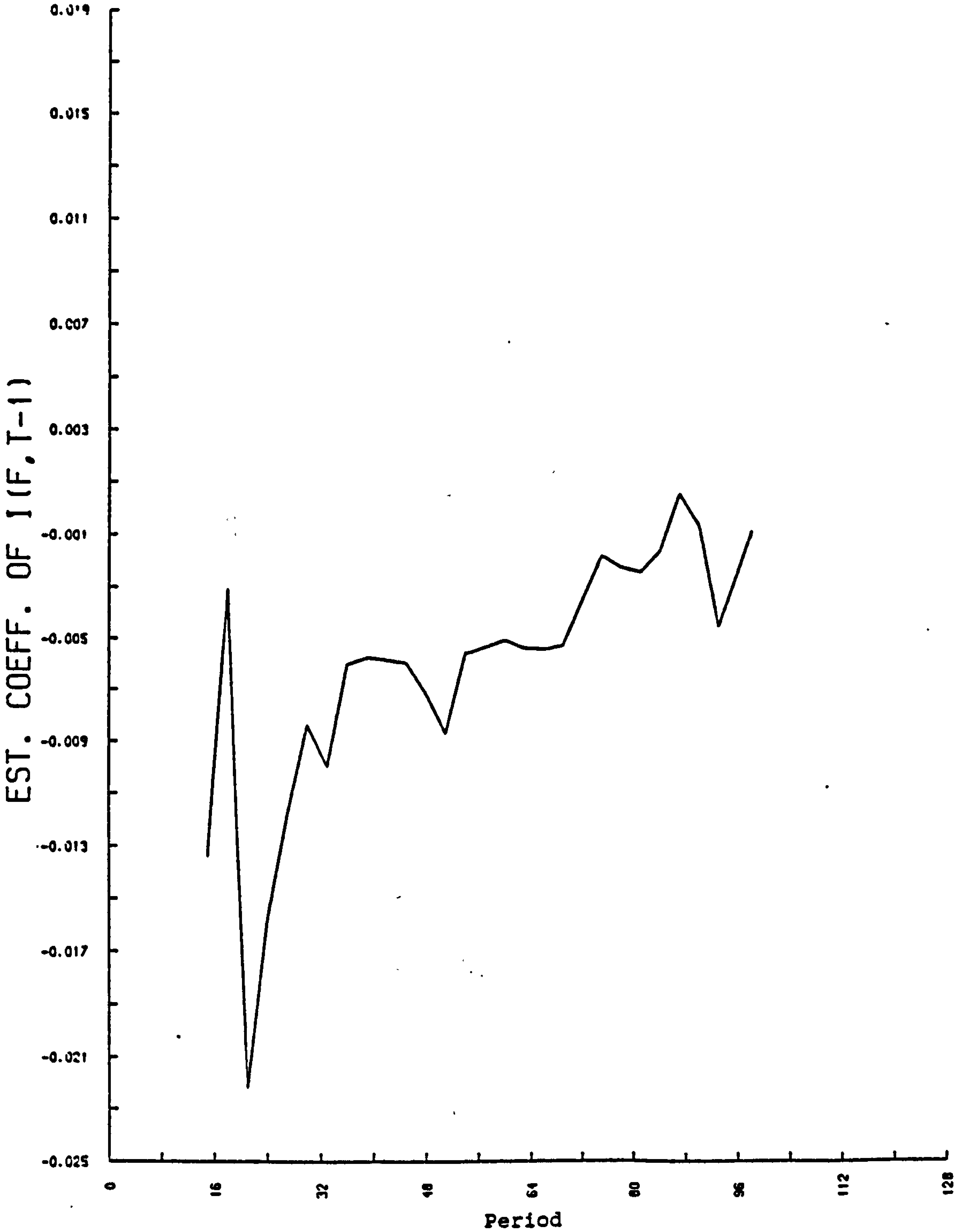


TABLE 2D

First Observation of Estimation Period(f)	Last Observation of Estimation Period(L)	Number of Additional Observations Tested For Conformity With First m Observations (n)	Calculated F-statistic	Calculated Modified F-statistic	m=1+ L-f	$F_{n,m-q}$ (q=d.f.) 95% Crit. Value	$F_{n,n+m-q}$ 95% Crit. Value
2	27	3	3.25	2.43	26	3.20	3.10
28	51	3	9.37	3.91	24	3.29	3.13
52	90	3	5.51	3.91	39	2.92	$F_{3,40}$=2.94

observation) it is surprising that there is as much variation as there is--especially in later estimations.

The local F-test (see section IV.D. of the monetary model chapter) was employed to provide quantitative and location specific evidence of structural breaks in the Dornbusch model as formulated here. Table 2D presents the results of this testing.

In the terminology of Briscoe and Roberts there is strong evidence of structural breaks near periods 51 (March 1976), and 90 (June, 1979) and weak evidence of a structural break near period 27 (March, 1974). It is interesting to note that only one of the breaks here identified (that at period 90) is the same place as one of those identified with the monetary model. The June, 1979 break coincides with the Thatcher Government's removal of restrictions on international investments, while the March, 1976 break comes at a time when restrictions on capital flows were being imposed.

E. Investigation of the Empirical Support for the Expectation Formation Equation

As discussed in section III of this chapter, it seems desirable to test the random walk assumptions implied by the use of equation 13 in the empirical version of this model to see if traders would be rational in using such an equation to calculate their expected long run steady state exchange rate.

Table 3D presents some regression results that provide simple tests of the hypotheses that the four exogenous variables in equation 13 each follow a random walk. Since in each case the regression which includes only one lagged variable is nested in the regression which includes two lagged variables, the log likelihood ratio may be used to test whether the additional lagged

TABLE 3D

Variable	Dependent Variable=lnMt		Dependent Variable=lnYt		Dependent Variable=lnPf,t		Dependent Variable=if,t	
$\ln M_{t-1}$	1.104(10.69)	0.988(280.54)						
$\ln M_{t-2}$	-0.115(1.13)							
$\ln Y_{t-1}$			0.904(9.44)	0.919(24.86)				
$\ln Y_{t-2}$			0.015(1.64)					
$\ln P_{f,t-1}$					1.552(17.80)	1.001(627.14)		
$\ln P_{f,t-2}$					-0.551(6.32)			
$i_{f,t-1}$							1.111(10.23)	0.996(30.49)
$i_{f,t-2}$							-0.123(1.11)	
Constant	0.125(3.18)	0.141(3.81)	.381(2.20)	.382(2.21)	.0018(.293)	.0028(.381)	.209(.718)	.156(.542)
$\bar{R}^2$	.999	.999	.866	.868	.9998	.9998	.908	.908
DW	2.02	1.77	2.06	2.09	2.14	.898	1 89	1.69
LLF	313.87	313.22	248.87	248.86	435.02	417.90	-119.88	-120.51
LLR	1.30		0.02		34.24		1.26	

Chi square critical value for n=1 75%=1.32, 90%=2.71, 95%=3.84, 99%=6.63

TABLE 4D

Variable	Dependent Variable=$\ln M_t$		Dependent Variable=$\ln Y_t$		Dependent Variable=$\ln P_{f,t}$		Dependent Variable=$i_{f,t}$	
$\ln M_{t-3}$	1.38(7.29)	0.963(143.73)						
$\ln M_{t-4}$	-0.413(2.21)							
$\ln Y_{t-3}$			0.569(4.29)	0.743(13.35)				
$\ln Y_{t-4}$			0.190(1.44)					
$\ln P_{f,t-3}$					2.327(10.49)	1.001(257.08)		
$\ln P_{f,t-4}$					-1.326(5.98)			
$i_{f,t-3}$							1.016(5.21)	.914(14.92)
$i_{f,t-4}$							-.109(.548)	
Constant	0.375(5.19)	0.424(6.04)	1.129(4.29)	1.205(4.64)	0.929(.604)	.0169(.936)	1.080(2.00)	1.027(1.94)
$\bar{R}^2$	.997	.996	.660	.656	.999	.999	.702	.704
DW	0.654	0.411	.595	.699	.846	.207	.659	.587
LLF	252.11	249.67	203.27	202.21	346.82	331.25	-173.70	-173.85
LLR	4.88		2.12		31.14		0.30	

TABLE 5D

Variable	Dependent Variable=$\ln M_t$		Dependent Variable=$\ln Y_t$		Dependent Variable=$\ln P_{f,t}$		Dependent Variable=$i_{f,t}$	
$\ln M_{t-6}$	1.434(4.77)	.930(85.51)						
$\ln M_{t-7}$	-.498(1.68)							
$\ln Y_{t-6}$			.476(2.86)	.627(8.88)				
$\ln Y_{t-7}$			.165(1.00)					
$\ln P_{f,t-6}$					3.129(7.93)	.995(142.27)		
$\ln P_{f,t-7}$					-2.133(5.41)			
$i_{f,t-6}$							.974(3.23)	.721(7.38)
$i_{f,t-7}$							-.269(.885)	
Constant	.732(6.14)	.797(6.99)	1.685(5.03)	1.75(5.32)	.0476(1.68)	.0654(2.03)	2.977(3.59)	2.864(3.50)
$\bar{R}^2$	.988	.988	.464	.464	.997	.996	.371	.373
DW	.300	.168	.365	.424	.508	.079	.305	.251
LLF	203.15	201.72	177.63	177.11	284.75	271.69	-201.45	-201.85
LLR	2.86		1.04		26.12		0.80	

TABLE 6D

Variable	Dependent Variable= $\ln M_t$		Dependent Variable= $\ln Y_t$		Dependent Variable= $\ln P_{f,t}$		Dependent Variable= $i_{f,t}$	
$\ln M_{t-12}$	1.463(3.03)	.855(46.75)						
$\ln M_{t-13}$	-.600(1.26)							
$\ln Y_{t-12}$			.410(1.88)	.423(4.00)				
$\ln Y_{t-13}$			.0154(.071)					
$\ln P_{f,t-12}$					3.638(5.29)	.963(79.38)		
$\ln P_{f,t-13}$					-2.670(3.89)			
$i_{f,t-12}$							.928(2.56)	.421(3.40)
$i_{f,t-13}$							-.538(1.48)	
Constant	1.555(7.66)	1.643(8.60)	2.694(5.26)	2.704(5.49)	.213(4.05)	.253(4.54)	5.761(5.69)	5.544(5.50)
$\bar{R}^2$	.963	.963	.141	.152	.989	.987	.125	.112
DW	.137	.064	.234	.238	.232	.037	.160	.102
LLF	152.75	151.93	145.00	145.00	222.03	214.82	-202.31	-203.44
LLR	1.64		0.00		14.42		2.26	

TABLE 7D

Variable	Dependent Variable=$\ln M_t$		Dependent Variable=$\ln Y_t$		Dependent Variable=$\ln P_{f,t}$		Dependent Variable=$i_{f,t}$	
$\ln M_{t-24}$	1.156(1.59)	.758(23.83)						
$\ln M_{t-25}$	-.391(.55)							
$\ln Y_{t-24}$			.215(.721)	.0702(.475)				
$\ln Y_{t-25}$			-.163(.560)					
$\ln P_{f,t-24}$					.517(.632)	.857(55.56)		
$\ln P_{f,t-25}$					.339(.416)			
$i_{f,t-24}$							-.0754(.204)	-.681(5.28)
$i_{f,t-25}$							-.641(1.75)	
Constant	2.677(7.46)	2.752(8.33)	4.433(6.28)	4.347(6.34)	.827(11.52)	.822(11.70)	14.062(13.91)	13.823(13.61)
$\bar{R}^2$	.886	.887	.0207	.0109	.977	.977	.292	.271
DW	.064	.041	.131	.125	.040	.041	.185	.159
LLF	104.35	104.20	113.89	113.73	180.81	180.72	-170.13	-171.83
LLR	0.30		0.26		0.18		3.40	

variable adds any explanatory power. If the two variable version proves preferable to the one variable version there will be evidence in favor of rejection of the null hypothesis. Of course the adjusted $\bar{R}^2$ of the one variable equation also provides a measure of the appropriateness of the random walk hypotheses as do the coefficient (which should be unity) and its t-statistic of the first order lagged variable.

On the basis of log likelihood ratios, the random walk hypothesis is rejected only in the case of $\ln P_{f,t}$ where it is strongly rejected. The $\bar{R}^2$ values for the regressions involving lnY and i_f, however, indicate that these variables might be better described by other functions than they are as random walks (the equations with two lagged variables are not, of course, the only possible alternative hypothesis).

It must be recalled, however, that the above study only tests the random walk hypotheses in their weakest forms. Traders expecting the long run steady state to be 3, 6, 12 or 24 months off will presumably require testing of equations of the forms of V.D.1, 2, 3, and 4, respectively,

V.D.1 $X_t = X_{t-3} + u_t$

2 $X_t = X_{t-6} + u_t$

3 $X_t = X_{t-12} + u_t$

4 $X_t = X_{t-24} + u_t$

before accepting equation 13 with present values plugged in for the explanatory variables as their expectations formation equation.

Tables 4D-7D provide regression results parallel to that presented in Table 3D but testing the random walk hypotheses in the forms represented by V.D.1-4 above, respectively.

As might be expected, the four independent variables are approximated decreasingly well as random walks the further off the long run steady state is assumed to be. This conclusion is born out by the deterioration of every statistic reported over the five tables presented. Of the few one lagged variable (forms of the random walk hypotheses) regressions to have $\bar{R}^2$'s of .980 or better all are rejected by their two lagged variable alternatives at the 90% significance level or better. From Table 4D on, all Durbin-Watson statistics provide strong evidence of autocorrelation. As the lag time is increased from Tables 3D to 7D the coefficients of the variables in the one lagged variable equations drift further and further from their theoretical value of one.

In short, the longer the period that traders believe the economy will require to reach the long run steady state, the less likely they will be satisfied to assume that $\ln M_t$, $\ln Y_t$, $\ln P_{f,t}$, and $i_{f,t}$ are well approximated as random walks, and the less happy they will feel about using equation 13 as it stands in forming their expectations of the long run steady state exchange rate.

F. Investigation of the Sensitivity of the Estimation to the Money Supply Measure Used

The sensitivity of the estimation of the Dornbusch model to the money supply measure used was studied using the same procedure used in section V.E. of the chapter on the monetary model. The regression reported in Table D1 was reestimated twice, first with M3 for M, and then again with M1 for M. The results are presented in Table 8D for qualitative comparison.

A quick glance indicates that the estimation is sensitive to the money supply measure used. This conclusion is supported by the values in Table 9D which are the result of Davidson and MacKinnon's J-test comparing the three estimations. Reported are the t-

TABLE 8D

Variable	Coeff's(t-stat) Original data (M=Stg M3)		Coeff's(t-stat) M=M3		Coeff's(t-stat) M=M1	
Constant	5.123	(5.11)	3.808	(4.39)	1.887	(1.31)
ln M_t	0.303	(.578)	-0.444	(1.03)	0.857	(1.92)
ln M_{t-1}	-1.471	(2.80)	-0.813	(1.91)	-0.373	(.845)
ln $P_{f,t}$	2.633	(5.35)	3.046	(7.22)	0.238	(.523)
ln P_{t-1}	-1.032	(4.73)	-1.141	(6.07)	-0.936	(2,89)
ln Y_t	-0.185	(.848)	-0.059	(0.312)	-0.542	(1.97)
ln Y_{t-1}	0.026	(.119)	0.109	(0.566)	-0.274	(1.01)
$i_{f,t}$	0.020	(3.65)	0.017	(3.49)	0.018	(2.69)
$i_{f,t-1}$	-0.008	(.126)	-0.0006	(0.114)	0.00004	(.005)
	$\bar{R}^2$ = .917, s.e. = .044		$\bar{R}^2$ = .939, s.e. = .038		$\bar{R}^2$ = .874, se = .055	
	DW =.359, LLF = 169.35		DW = .364, LLF = 184.14		DW =.283, LLF = 149.52	

statistics of the coefficients of the alternative hypothesis variables--all of which are significant at any reasonable level of significance (for n=60 99% c.v.=2.39). It must be concluded, therefore, that there is evidence that estimation of the present model is sensitive to the money supply measure used.

Table 9D

		H_1		
		Stg M3	M3	M1
	Stg M3	X	10.15	4.32
H_o	M3	5.16	X	3.63
	M1	8.53	10.81	X

G. Investigation of the Sensitivity of the Estimation to the Price Level Measure Used.

Sensitivity of the estimation to the price level measure used was studied by reestimating the regression reported in Table 1D twice--first using the UK's export prices (XP) for P, and then using the UK's unit labor cost (ULC) for P. The three estimations are reported in Table 10D for comparison.

Qualitative examination of the results in Table 10D would lead one to conclude that the estimation is sensitive to the price level measure used. It is useful to point out that of the three estimations, that using export prices is "best" in terms of having the highest $\bar{R}^2$, DW statistic, and log likelihood function and the lowest standard error. Yet, of the of three price level measures, export prices are argueably the least appropriate for use with this model--among other reasons, because they do not include non-traded goods. This example serves to illustrate and underline the point made

TABLE 10D

Variable	Coeff's(t-stat) Original data (M= Stg M3)		Coeff's(t-stat) M=M3		Coeff's(t-stat) M=M1	
Constant	5.123	(5.11)	7.368	(13.07)	8.206	(9.33)
ln M_t	0.303	(.578)	-0.200	(.503)	0.060	(.102)
ln M_{t-1}	-1.471	(2.80)	-0.223	(.564)	-0.957	(1.64)
ln $P_{f,t}$	2.633	(5.35)	-1.214	(5.83)	0.752	(1.28)
ln P_{t-1}	-1.032	(4.73)	0.739	(10.11)	-0.137	(.553)
ln Y_t	-0.185	(.848)	-0.121	(.732)	-0.342	(1.41)
ln Y_{t-1}	0.026	(.119)	-0.120	(.714)	-0.129	(.504)
$i_{f,t}$	0.020	(3.65)	0.0069	(1.59)	0.016	(2.50)
$i_{f,t-1}$	-0.0008	(.126)	0.0068	(1.56)	0.014	(2.12)
	$\bar{R}^2$ = .917, se = .044		$\bar{R}^2$ = .952, s.e. = .034		$\bar{R}^2$ = .897, s.e. = .050	
	DW = .359, LLF = 169.35		DW = .519, LLF = 195.73		DW = .310, LLF = 158.52	

in section IV. of the monetary model chapter, namely that the choice of the appropriate data set for use with a model under study may not be made on the basis of which data set produces the nicest estimation.

Table 11D, which reports the t-statistics of the coefficients of the alternative hypothesis variables from the various J-tests comparing the three estimations, provides quantitative support for the conclusion drawn on the basis of Table 10D. All values reported are significant at the 99% significance level (n=60 c.v. =2.39) except the H_0=CPI, H_1=ULC case for which the reported value is insignificant at the 90% level (n=60 c.v. =1.296). It may therefore be concluded that there is evidence that estimation of the present model is sensitive to the choice of price level measure used.

Table 11D

		H_1		
		CPI	XP	ULC
	CPI	X	9.56	1.15
H_0	XP	4.07	X	3.74
	ULC	4.84	11.43	X

VI. Conclusions

As was the case with the monetary model, the most outstanding result of this chapter is the conclusion that the Dornbush based empirical model developed and studied here is dynamically misspecified. It seems that the increase in dynamic sophistication of this model relative to the simple monetary model is insufficient to alleviate this shortcoming.

Other conclusions are as follows:

1) On the basis of J-tests, the Dornbusch based model is not superior to the monetary model--the tests indicate that neither is the "true" model.
2) The coefficients estimated for the model do not correspond well to those theoretically predicted.
3) There is evidence of three structural breaks over the period estimated.
4) The random walk assumptions implied by the use of equation 13 as the expectations formation equation are reasonable only if the steady state is assumed to be a short run phenomenon.
5) The estimation is sensitive to the money supply measure used.
6) The estimation is sensitive to the price level measure used.

The Stock/Flow Model

I. Introduction

In this last of three empirical chapters I develop a model with still one more degree of dynamic sophistication, having found both the monetary and Dornbusch models to be deficient in this respect. The stock/flow model presented and studied here involves the added sophistication that capital is no longer assumed to be perfectly mobile, meaning that domestic and foreign interest rates are no longer necessarily equalized, and domestic and foreign assets are no longer perfect substitutes.

The stock/flow model is developed in section II, and the data used in estimation are discussed in section III. Empirical work on the model is presented in section IV along the same lines as that work presented in the two preceding chapters. Section V concludes.

II. Development of a Stock/Flow Type Model

From the monetary model, only the money market equilibrium equation,

(2) $\ln M \; (=\ln M^d) = \ln\alpha + \beta\ln P + \gamma\ln Y - \delta i$

is included in the stock/flow model.

From the Dornbusch model developed in the last chapter, both the partial adjustment of prices equation,

(8) $\Delta\ln P = \Phi[u + (a-1)\ln Y - bi + c\ln(P_f/PS)]$

and expectations formation equation,

(9) $E(\hat{S}) = \Psi(\ln\bar{S} - \ln S)$

(where Ψ is a linear function and $0<\Psi<1$) remain intact in the stock/flow model.

The step forward in sophistication included in the stock/flow model is that perfect capital mobility, resulting in uncovered interest parity is no longer assumed. Domestic and foreign assets are no longer assumed to be perfect substitutes--one may have a higher expected yield than the other.

Imperfect capital mobility is built into the model by replacing equation (5) from the monetary model with

(17) $\Delta B + T = 0.$

Net capital inflows, ΔB, plus the trade balance, T, must equal zero under a floating exchange rate regime (assuming net reserve transactions plus errors and ommissions equal zero.)

If we assume that net demand from abroad for domestic assets, B, is a linear function of the expected relative yield on domestic assets,

(18) $B = \Omega[i - i_f + E(\hat{S})]$

and the trade balance is a linear function of relative prices and foreign and domestic income levels,

(19) $$T = \rho \ln(P_f/SP) - \sigma \ln Y + \sigma_f \ln Y_f$$

then we get (combining 9, 17, 18, and 19),

(20) $$i = \frac{\rho}{\Omega}\ln P - \frac{\rho}{\Omega}\ln P_f + \frac{\sigma}{\Omega}\ln Y - \frac{\sigma_f}{\Omega}\ln Y_f + i_f + (\psi + \frac{\rho}{\Omega})\ln S - \psi \ln \bar{S} + \frac{1}{\Omega}B_{t-1}.$$

Lagging 18 to get rid of Bt-1 would introduce moving average character into the error term of the estimated model since 18 contains endogenous variables.

Imposing the steady state ($S=\bar{S}$, $P=\bar{P}$, $i=i_f$, and $\Delta P=0$) on equations 2 and 8, respectively, gives

($\bar{2}$) $$\ln \bar{P} = \frac{1}{\beta}\ln M - \frac{1}{\beta}\ln \quad - \frac{\gamma}{\beta}\ln Y + \frac{\delta}{\beta}i_f$$

($\bar{8}$) $$\ln \bar{S} = \frac{u}{c} + \frac{(a-1)}{c}\ln Y - \frac{b}{c}i_f + \ln P_f - \ln \bar{P}.$$

Combining these two equations, we get (the same as eg.13 from the Dornbusch model)

(21) $$\ln \bar{S} = (\frac{u}{c} + \frac{\ln \alpha}{\beta}) - \frac{1}{\beta}\ln M + (\frac{a-1}{c} + \frac{\gamma}{\beta})\ln Y + \ln P_f$$
$$(\frac{b}{c} + \frac{\delta}{\beta})i_f$$

which, along with equation 20, is substituted into equation 2 to give a short run exchange rate equation:

(22) $$\ln S = \frac{\ln \alpha}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{(\frac{u}{c} + \frac{\ln \alpha}{\beta})}{(1 + \frac{\rho}{\Omega\psi})} - \left[\frac{1}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{\psi}{\beta(\psi + \frac{\rho}{\Omega})}\right]\ln M$$
$$+ \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\ln P + \ln P_f + \frac{\sigma_f}{\Omega\psi + \rho}\ln Y_f$$
$$+ \frac{\frac{\gamma}{\delta} - \frac{\sigma}{\Omega} + \psi(\frac{a-1}{c} + \frac{\gamma}{\beta})}{\psi + \frac{\rho}{\Omega}}\ln Y - \frac{1}{\Omega\psi + \rho}B_{t-1}$$
$$- \frac{1 + \psi(\frac{b}{c} + \frac{\delta}{\beta})}{\psi + \frac{\rho}{\Omega}}i_f.$$

We can however, capture more of our theoretical model in an equation to be estimated by using the goods market equation 8 to include short run partial price adjustments toward the long equilibrium price level (as we did with the Dornbusch model.)

First, we combine equations 2, 8, and 22 to get an equation for $\ln P_{t+1}$ in exogenous variables:

$$(23) \qquad \ln P_{t+1} = \varphi\left[u - \frac{b\ln\alpha}{\delta} - \frac{c\ln\alpha}{\delta(\psi + \frac{\rho}{\Omega})} - \frac{u + c\ln\alpha}{1 + \frac{\rho}{\Omega\psi}}\right]$$

$$+ \varphi\left[\frac{b}{\delta} + \frac{c}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{c}{\beta(\psi + \frac{\rho}{\Omega})}\right]\ln M$$

$$+ \left[1 - \varphi c - \frac{\beta\varphi b}{\delta} - \frac{\varphi c(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{\psi + \frac{\rho}{\Omega}}\right]\ln P$$

$$+ \varphi\left[(a-1) - \frac{b\gamma}{\delta} - \frac{c(\frac{\gamma}{\delta} - \frac{\sigma}{\Omega} + \psi\left[\frac{a-1}{c} + \frac{\gamma}{\beta}\right])}{\psi + \frac{\rho}{\Omega}}\right]\ln Y$$

$$- \frac{\varphi c\sigma_f}{\Omega\psi + \rho}\ln Y_f + \frac{\varphi c + \varphi\psi(b + \frac{c\delta}{\beta})}{\psi + \frac{\rho}{\Omega}}\, i_f$$

$$+ \frac{\varphi c}{\Omega\psi + \rho} B_{t-1}$$

which can be lagged (without introducing moving average character into the implied error term) and plugged back into 22 to get:

$$\text{(24)} \qquad \ln S = \frac{\ln\alpha}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{(\frac{u}{c} + \frac{\ln\alpha}{\beta})}{(1 + \frac{\rho}{\Omega\psi})}$$

$$+ \frac{\varphi(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\left[u - \frac{b\ln\alpha}{\delta} - \frac{c\ln\alpha}{\delta(\psi + \frac{\rho}{\Omega})} - \frac{(u + \frac{c\ln\alpha}{\beta})}{1 + \frac{\rho}{\Omega\psi}}\right]$$

$$- \left[\frac{1}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{\psi}{\beta(\psi + \frac{\rho}{\Omega})}\right]\ln M$$

$$+ \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\left[\frac{b\varphi}{\delta} + \frac{c\varphi}{\delta(\psi + \frac{\rho}{\Omega})} + \frac{\varphi c\psi}{\beta(\psi + \frac{\rho}{\Omega})}\right]\ln M_{t-1}$$

$$+ \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\left[1 - \varphi c - \frac{\beta\varphi b}{\delta} - \frac{\varphi c(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\right]\ln P_{t-1}$$

$$+ \ln P_f + \frac{\frac{\gamma}{\delta} - \frac{\sigma}{\Omega} + \psi(\frac{a - 1}{c} + \frac{\gamma}{\beta})}{\psi + \frac{\rho}{\Omega}}\ln Y$$

$$+ \frac{\frac{\beta}{\delta} - \frac{\rho}{\Omega}}{\psi + \frac{\rho}{\Omega}}\left[\varphi(a-1) - \frac{\varphi b\gamma}{\delta} - \frac{\varphi c[\frac{\gamma}{\delta} - \frac{\sigma}{\Omega} + \psi(\frac{a-1}{c} + \frac{\gamma}{\beta})]}{\psi + \frac{\rho}{\Omega}}\right]\ln Y_{t-1}$$

$$+ \frac{\sigma_f}{\Omega\psi + \rho}\ln Y_f - \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})}{(\psi + \frac{\rho}{\Omega})}\frac{(\varphi c\sigma_f)}{(\Omega\psi + \rho)}\ln Y_{f,t-1}$$

$$- \frac{[1+\psi(\frac{b}{c} + \frac{\delta}{\beta})]}{(\psi + \frac{\rho}{\Omega})}i_f + \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})[\varphi c+\varphi\psi(b + \frac{c\delta}{\beta})]}{(\psi + \frac{\rho}{\Omega})^2}i_{f,t-1}$$

$$- \frac{1}{\Omega(\psi + \frac{\rho}{\Omega})}B_{t-1} + \frac{(\frac{\beta}{\delta} - \frac{\rho}{\Omega})\varphi c}{(\psi + \frac{\rho}{\Omega})(\Omega\psi + \rho)}B_{t-2}.$$

III. Data

Most of the data required for estimation of the stock/flow model was the same as that used in estimation of the monetary and/or the Dornbusch models estimated previously. Consequently, the data problems discussed in the contexts of these two previous models still apply in the present estimation.

Estimation of the stock/flow model was further complicated, however, by the presence of capital stock variables. Data that might be appropriate to be used for such variables is available only on a quarterly basis for the UK. The choice, therefore, seemed to be between switching to another country's data for estimation of this model (Japan and West Germany both provide capital account data on a monthly basis) and using quarterly data for this estimation. In the former case, the structural breaks identified would not bear any likely relation to those identified for the UK in the two previous studies. In the latter case, the quest for dynamically more sophisticated model might become irrelevant--the switch to quarterly data alone might solve the misspecification problem.

For now, the decision was made to continue using UK data with the view that follow up empirical work on these three models should be done using other countries' data.

Such follow up work might provide broader support for the conclusions drawn in this study.

Quarterly capital stocks data were calculated from quarterly capital flows data published by the Central Statistical Office. Quarterly price data were calculated from the monthly data provided by H&T. Quarterly data for all other variables were obtained as described in section V.G of the monetary model chapter.

IV. Empirical Work on the Stock/Flow Model

A. Quarterly Data Estimation of the Stock/Flow Model and Comparison to the Monetary Model, the Dornbusch Model, and a Modified Version of the Stock/Flow Model

Table 1SF presents the results of the OLS estimation of equation 24 using quarterly data as indicated in section III.

Of the five coefficients that are predictable *a priori*, only those of $\ln M_t$, $\ln Y_{f,t}$ and $\ln P_{f,t}$ have the predicted signs and the first two are not significantly different from zero. The coefficient of $\ln P_{f,t}$ is only a little over one standard deviation away from its predicted value of unity and so is not significantly different from that prediction (c.v. at the 90% level for n=30 is 1.31). Only the coefficient of $i_{f,t}$ is significantly different from its predicted sign (c.v. at the 95% level for n=30 is 1.70).

The Durbin-Watson statistic for this estimation of 1.736 is in the gray region (for n=30 and k=5, d_L=1.07 and d_U=1.83) leaving the question of presence of autocorrelation unresolved. As mentioned earlier, the apparent progress in moving the DW statistic from below d_L in the Dornbusch model estimation of the previous chapter toward d_U in the present estimation is more likely due to the switch from monthly to quarterly data than to any dynamic sophistications introduced.

In light of the very small and statistically insignificant coefficients of the capital stock variables, it was decided that, in addition to comparing the present estimation to quarterly estimations of the monetary and Dornbusch models, a modified version of the stock/flow model--dropping out the two capital stock variables--would be estimated for comparison.

TABLE 1SF

Variable	Estimated Coeff(t-stat) S/F		Estimated Coeff(t-stat) Modified S/F		Theoretical Predictions about Coeff's
C	4.795	(1.76)	4.537	(1.79)	none
$\ln M_t$	-0.232	(0.433)	-0.316	(0.639)	<0
$\ln M_{t-1}$	-0.974	(1.64)	-0.995	(1.75)	none
$\ln P_{t-1}$	-0.710	(1.47)	-0.814	(1.88)	none
$\ln P_{f,t}$	2.292	(2.03)	2.544	(2.49)	=1
$\ln Y_t$	0.344	(0.746)	0.315	(0.714)	none
$\ln Y_{f,t}$	0.496	(0.692)	0.622	(0.998)	>0
$\ln Y_{t-1}$	0.479	(1.02)	0.501	(1.12)	none
$\ln Y_{f,t-1}$	-1.405	(2.30)	-1.365	(2.35)	none
$i_{f,t}$	0.014	(1.79)	0.013	(1.91)	<0
$i_{f,t-1}$	0.015	(1.90)	0.014	(1.86)	none
B_{t-1}	0.0000016	(0.165)			<0
B_{t-2}	-0.000007	(0.688)			none
	$\bar{R}^2$=.923, se=.039		$\bar{R}^2$=.929, se=.038		
	DW=1.736, LLF=63.13		DW=1.66, LLF=62.66		

Table 2SF presents the statistics used in comparison of the four models. Because it is not nested in any of the other models, the monetary model was compared to the other three by using the J-test. Thus, where the monetary model is involved, the statistic reported is the t-statistic of the estimated coefficient of the alternative hypothesis variable. The Dornbusch and modified stock/flow models, on the other hand, are nested in the stock/flow model and so the log likelihood test was used to compare these three models. The statistic reported in these cases are log likelihood ratios of the null hypothesis to the alternative hypothesis (e.g. a positive LLR means the null hypothesis has the larger LLF, and a negative LLR means the alternative hypothesis has the larger LLF).

TABLE 2SF

		H_1			
		Monetary	Dornbusch	S/F	Mod. S/F
H_o	Monetary	X	t=3.19	t=4.34	t=4.08
	Dornbusch	t=1.93	X		
	S/F	t=1.24	LLR=6.14	X	LLR= 0.94
	Mod. S/F	t=0.81	LLR=5.20		X

Before assessing these results, it is important to remember that both the J-test and the LLR test have asymptotic properties. Because of this, the 30 observations used in the estimations being compared may not be sufficient to give reliable results with these tests.

Looking first at the t-statistics reported, where the 95% critical value for n=20 is 1.7 and the 90% critial value is 1.3, we see that the monetary model is rejected by each of the other three models. The Dornbusch model is rejected by the monetary model, but neither the stock/flow nor the modified stock/flow model is rejected by the monetary model. On the basis of these results, we may conclude that the two stock/flow type models are significantly better at explaining the exchange rate than the monetary model whereas the Dornbusch model is not significantly better.

Turning to the LLR tests, where for n=2 and n=4, respectively, the 95% critical values are 5.99 and 9.49 and the 90% critical values are 4.61 and 7.78, the results are less clear cut. The stock/flow and modified stock/flow models cannot be said to be different at any reasonable level of significance. Neither does the stock/flow model show itself to be superior to the Dornbusch model at the 90% level or better. The modified stock/flow model, however, is significantly better than the Dornbusch model at the 90% level (though not at the 95% level.)

The first LLR result--the nearly identical levels of explanatory powers of the stock/flow and the modified stock/flow models--along with the similarity of the S/F and modified S/F models as indicated in Table 1SF, opened up a possible escape from the problems of working with quarterly data. If it is assumed that this similarity would hold with monthly estimations in the way it was shown to hold using quarterly estimations, then we might revert to monthly data for subsequent testing and use the modified stock/flow model as a proxy for the stock/flow model developed in section II. Although it is risky to assume that the monthly result would mimic the quarterly result, it was decided that the added degrees of freedom afforded by using monthly data which, among other things, allow much more rigorous study of the structural stability of the model, made the risk worth taking. It must be born in mind when viewing the following results that the degree to which they are relevant to the stock/flow model depends on the reasonableness of the above assumption.

B. Monthly Data Estimation of the Modified Stock/Flow Model and Comparison to the Monetary and Dornbusch Models

Table 3SF contains the results of the OLS estimation of the modified stock/flow model (equation 24 less the two capital stock variables) using Hacche and Townend's monthly data.

TABLE 3SF

Variable	Estimated Coeff (t-stat)	Theoretical Predictions about Coeff
C	5.024 (4.77)	none
$\ln M_t$	0.429 (0.905)	<0
$\ln M_{t-1}$	-1.613 (3.39)	none
$\ln P_{f,t}$	2.789 (5.23)	=1
$\ln P_{t-1}$	-1.068 (4.25)	none
$\ln Y_t$	0.013 (0.062)	none
$\ln Y_{t-1}$	0.321 (1.52)	none
$\ln Y_{f,t}$	1.589 (2.88)	>0
$\ln Y_{f,t-1}$	-2.142 (3.88)	none
$i_{f,t}$	0.020 (3.93)	<0
$i_{f,t-1}$	0.002 (0.318)	none
	$\bar{R}^2$=.933, se=.040	
	DW=0.684.LLF=180.44	

Of the four _a priori_ predictable coefficients, only that of $\ln Y_{f,t}$ is consistent with theory, being significantly greater than zero (for n-60 the 95% t-statistic critical value is 1.67) The coefficients of $i_{f,t}$ (being significantly greater than zero when it is predicted to be negative) and $\ln P_{f,t}$ (being more than three standard deviations away from its predicted value of unity) are at odds with theory, while the coefficient of $\ln M_t$ is not significantly different from zero and so may not be judged.

The Durbin-Watson statistic clearly points to the presence of autocorrelation (for n=90, and k=5 at the 95% level d_L=1.56). Section III.C. will look into the possibility that this autocorrelation is the result of dynamic misspecification.

The modified stock/flow model was compared to the monetary model using the J-test and to the Dornbusch model (which is nested in the modified stock/flow model) using the simple LLR test. In the former test, the t-statistics of the estimated coefficients of the alternative hypothesis variables with the monetary model and the modified stock/flow model, respectively, cast as the null hypothesis were 5.98 and 2.08 (the 95% c.v. for n=60 is 1.67). Thus we have mutual rejection and neither model can be said to be better than the other on the basis of this test.

The log likelihood ratio comparing the modified stock/flow model to the Dornbusch model is 22.18 (95% χ^2 c.v. for n=2 is 5.99) indicating that the two models are significantly different. The perhaps surprising outcome that the modified stock/flow model is significantly better than the Dornbusch model, but not significantly better than the monetary model may be nothing more than discrepency in the tests used.

C. Investigation of the Possibility of Dynamic Misspecification

As reported in section IV.B., estimation of the stock/flow model with monthly data pointed to the presence of autocorrelation. The model was therefore tested, using the test of common factors described previously, to see if the autocorrelation was the result of dynamic misspecification.

The log likelihood ratio comparing the unrestricted first order lagged OLS estimation to the estimation using the Cochrane-Orcutt autoregressive technique was 5.63. This value is below even the 50% significance level chi squared critical value for n=7 of 6.35. It must be concluded, therefore, that on the basis of this test, there is no evidence that the present formulation of the stock/flow model is dynamically misspecified.

Support for this conclusion comes from estimations of the stock/flow and modified stock/flow model using quarterly data. The relevant LLR's for the stock/flow and modified stock/flow models, respectively, are 12.80 and 11.00. Neither of these is significant at the 90% level where the critical values are 13.4 for n=8, and 12.0 for n=7.

D. Investigation of the Sensitivity of the Misspecification Test to the Data Used

Reverting again to monthly data and the modified version of the stock/flow model, the common factor test was repeated using different data sets to test the sensitivity of the conclusion to the data used. As in section V.C. of the Dornbusch chapter, two retests of the common factor hypothesis were done using M1 and M3 in place of sterling M3 for domestic money supply, and two retests were done using export prices and unit labor costs in place of the consumer price index for the domestic price level.

In the first pair of retests, the log likelihood ratios comparing the unrestricted first order lagger OLS estimation of the model to its Cochrane-Orcutt autoregressive estimation were 21.50 and 26.64, respectively, in the cases that M1 and M3 were used as data for the domestic money supply. Each of these values is larger than the 99% Chi squared critical value for n=7 of 18.5. Thus, on the basis of these tests, there is evidence that the present version of the stock/flow model is misspecified.

In the second pair of retests, in which export price data and unit labor cost data respectively, were used for the domestic price level, the relevant LLR's were 22.08 and 31.54. Again, these may be compared to the 99% χ^2 critical value of 18.5. These retests, agreeing with the first pair of retests and so at odds with the results of section IV.C., indicate that the stock/flow model as formulated is dynamically misspecified.

Thus the conclusion of section IV.C. is weakened and must be stated as being dependent on the data used.

E. Investigation of the Possibility of Structural Breaks

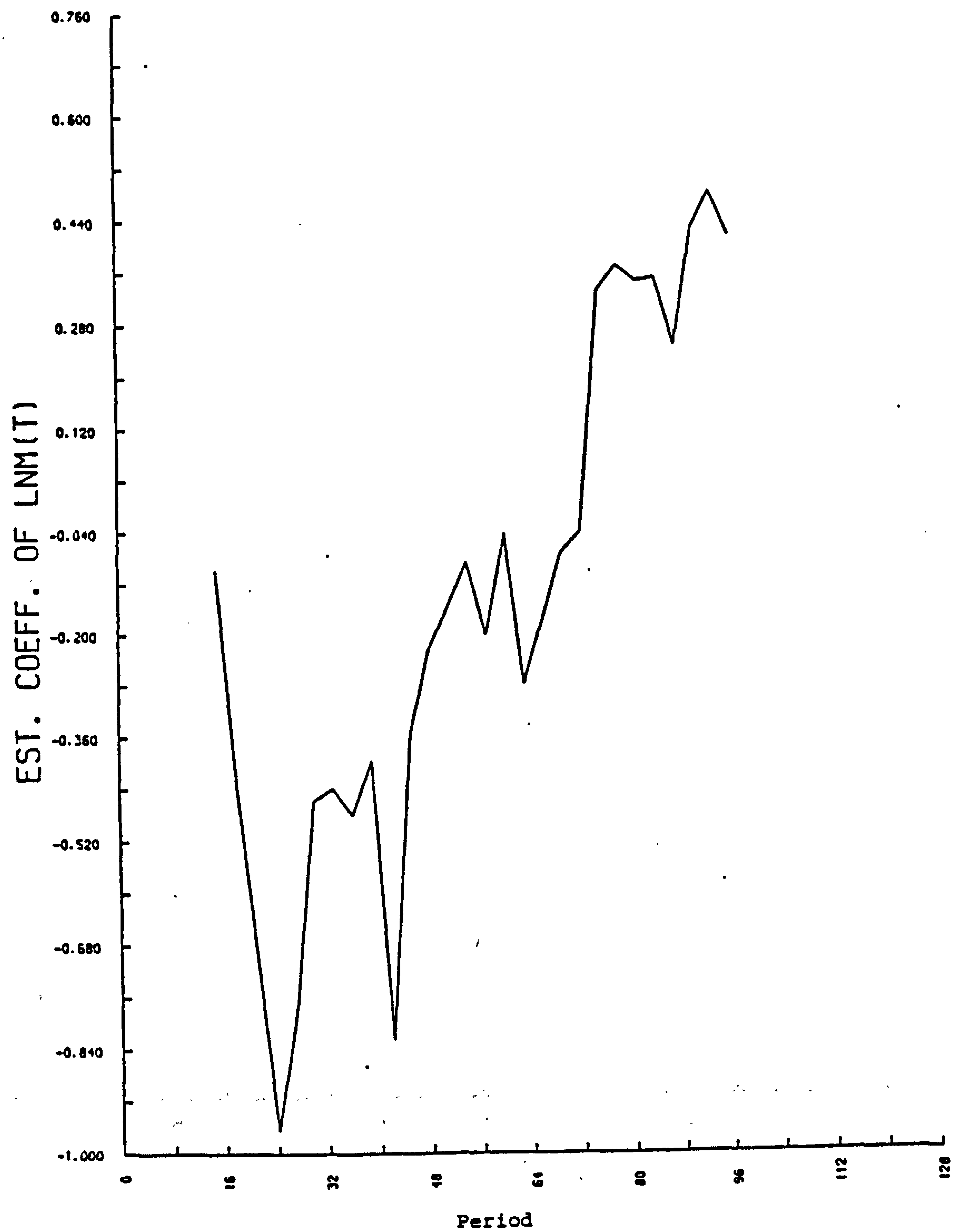
The possibility of structural breaks in the monthly data estimation of the modified stock/flow model was explored using the same techniques used in the previous two chapters.

Again, graphical methods were employed to get a preliminary feel for the constancy of the estimated coefficients over time. As was the case in section IV.D. of the Dornbusch chapter, the structural equations of this model are underidentified and so it is the estimated reduced form coefficients that were plotted.

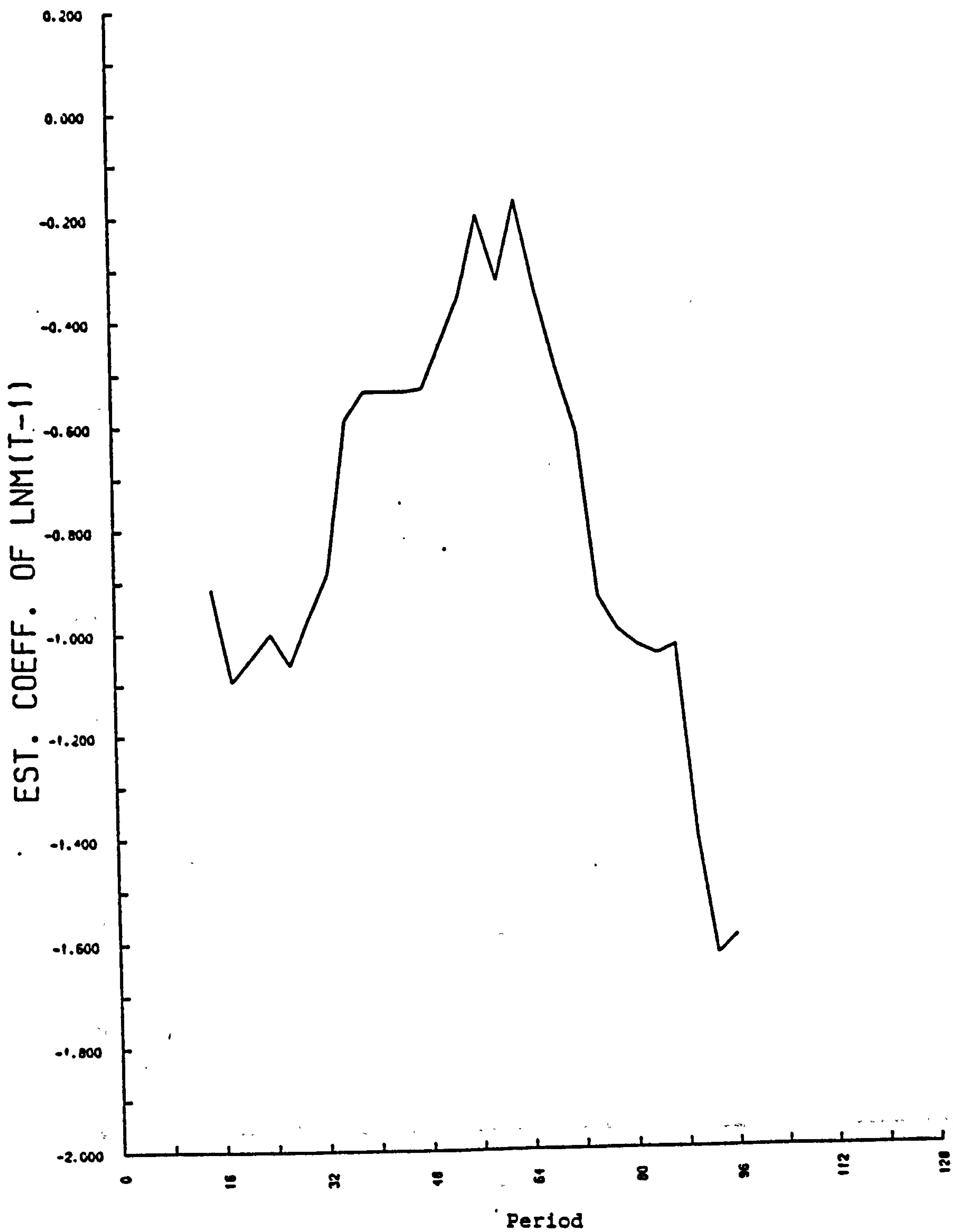
Graphs 1SF-10SF provide considerable evidence that the reduced form coefficients are not constant over time.

In search of quantitative support for, or rejection of, this qualitative evidence the local F-test was used (see section V.D. of the monetary chapter for

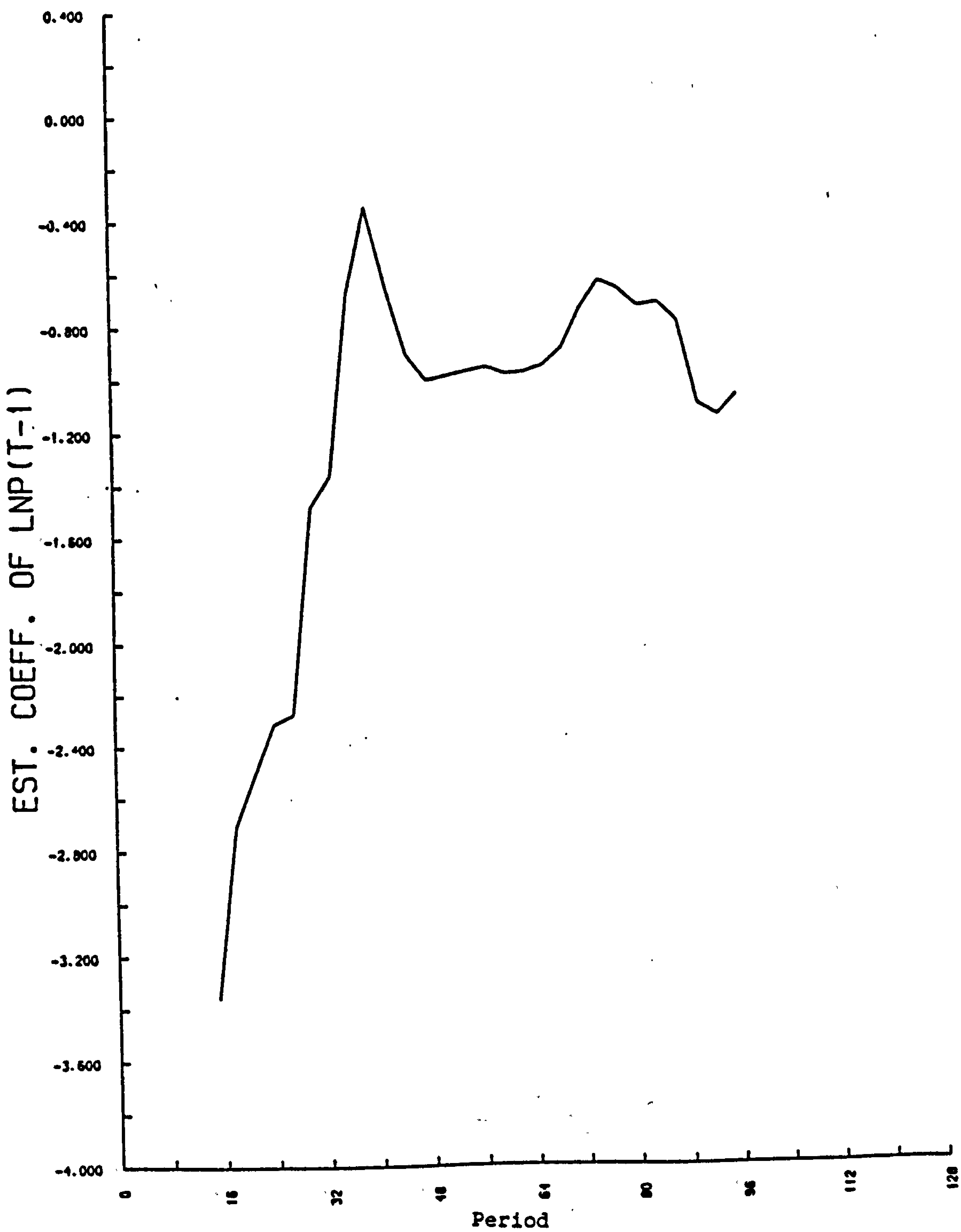
Graph 15F: Variation in the Estimation of the Coefficient of $\ln M_t$ Over Time



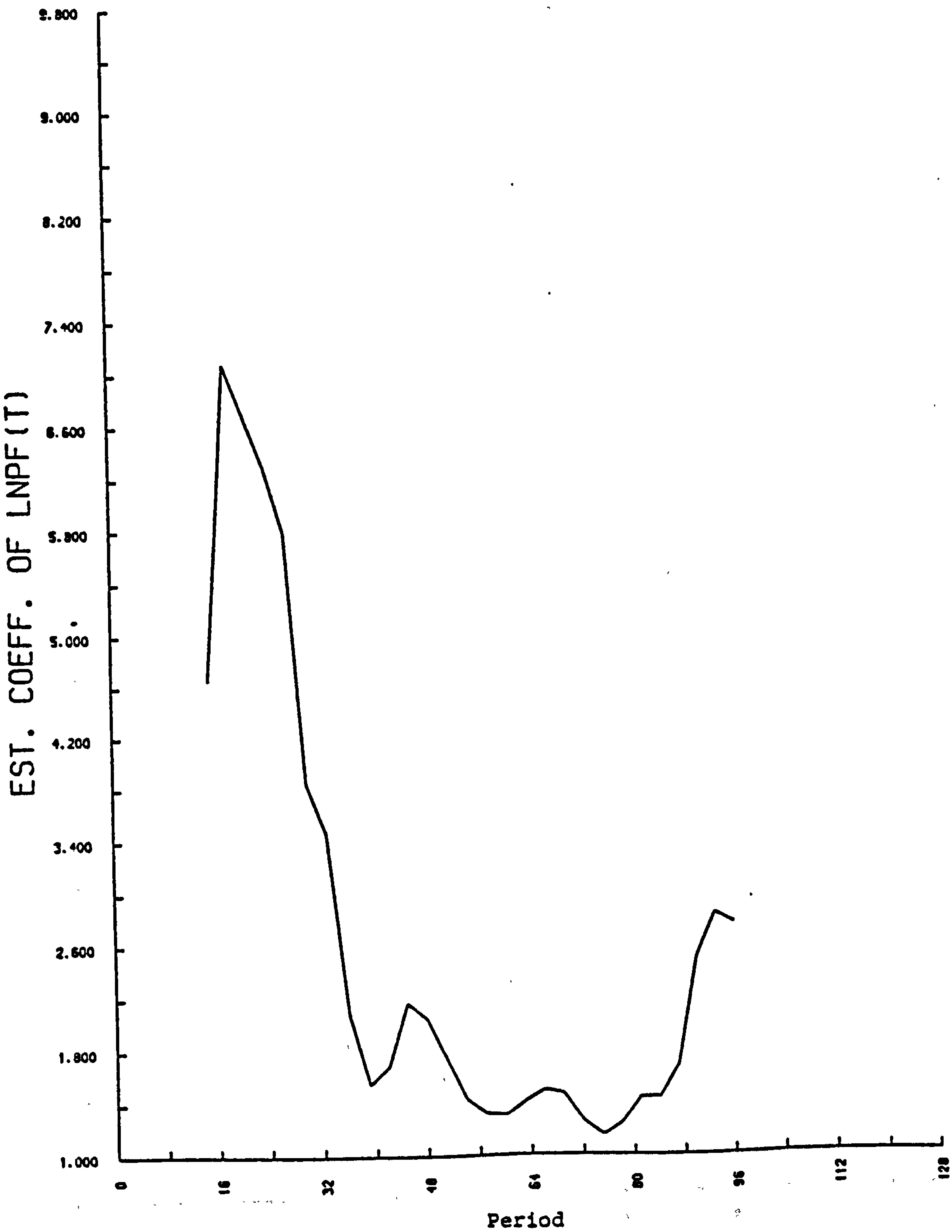
Graph 2SF: Variation in the Estimation of the Coefficient of $\ln M_{t-1}$ Over Time



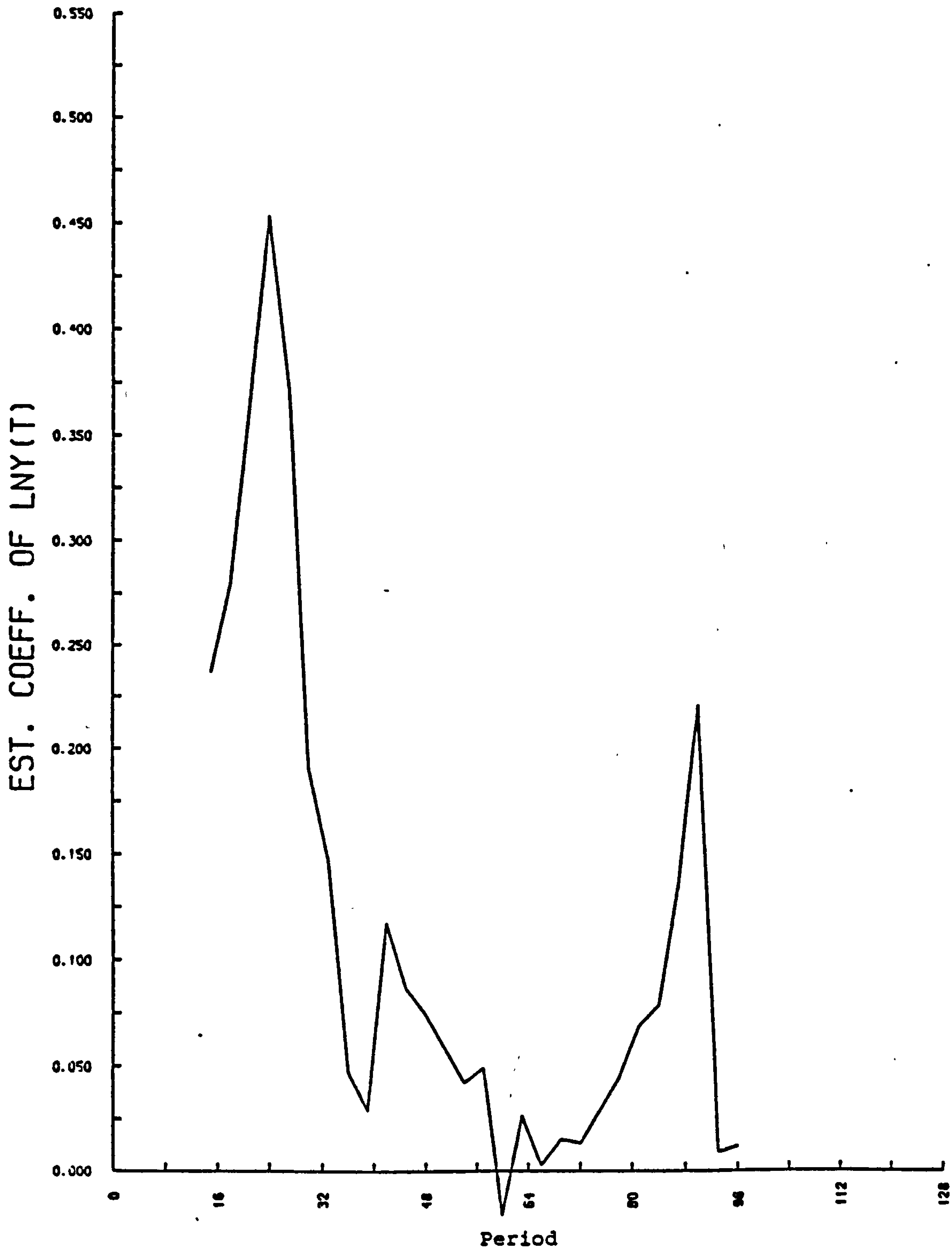
Graph 3SF: Variation in the Estimation of the Coefficient of $\ln P_{t-1}$ Over Time



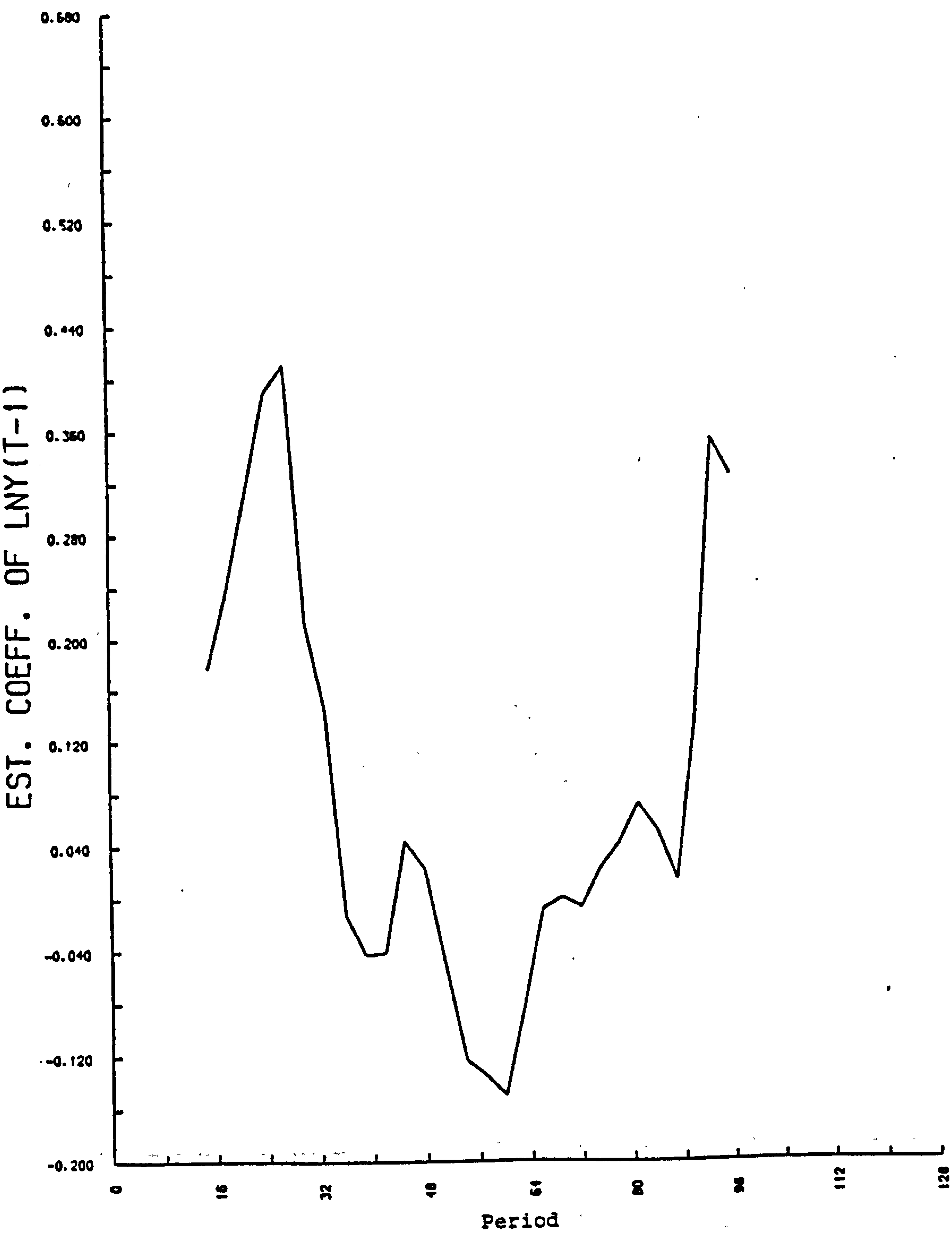
Graph 4SF: Variation in the Estimation of the Coefficient of $\ln P_{f,t}$ Over Time



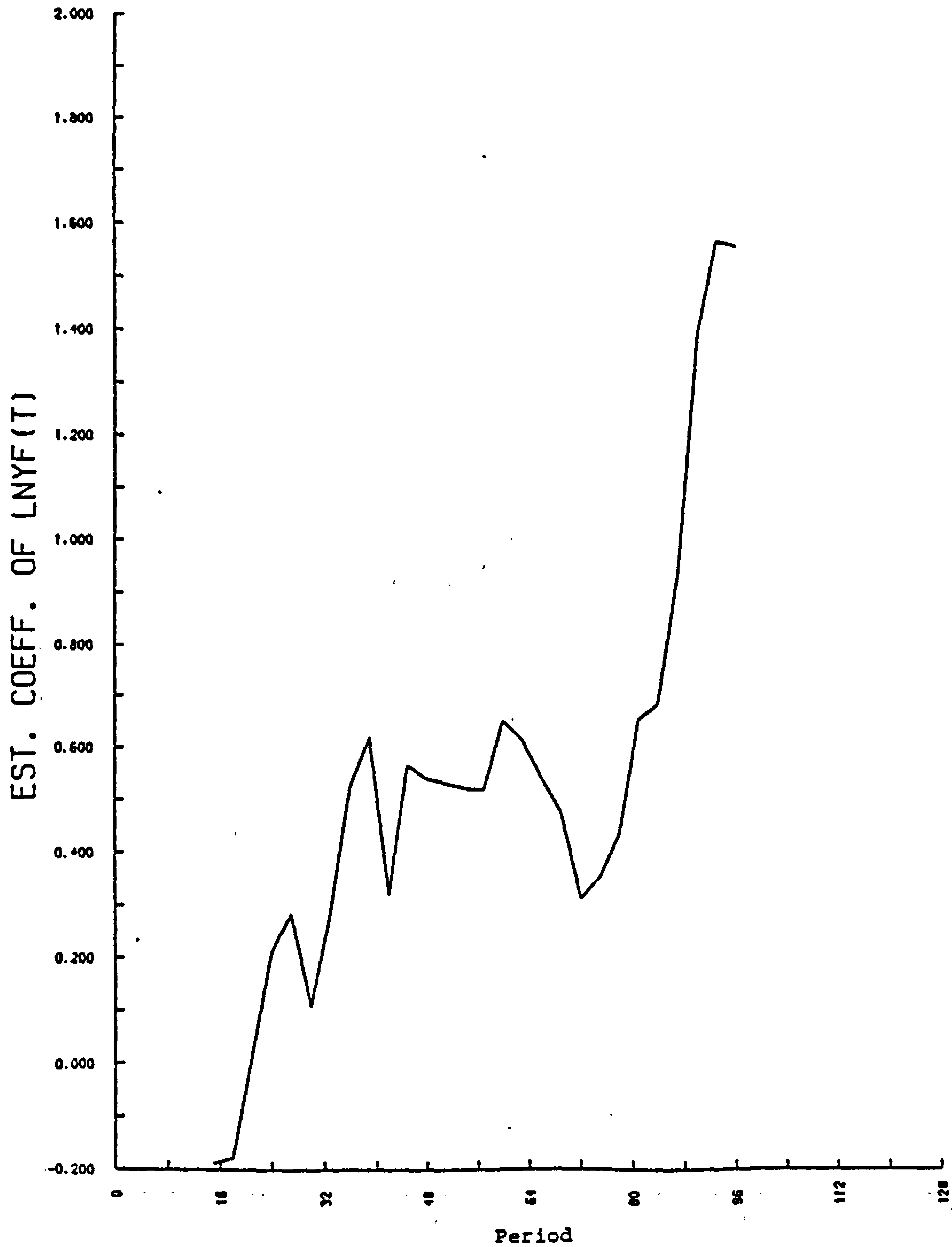
Graph 5SF: Variation in the Estimation of the Coefficient of $\ln Y_t$ Over Time



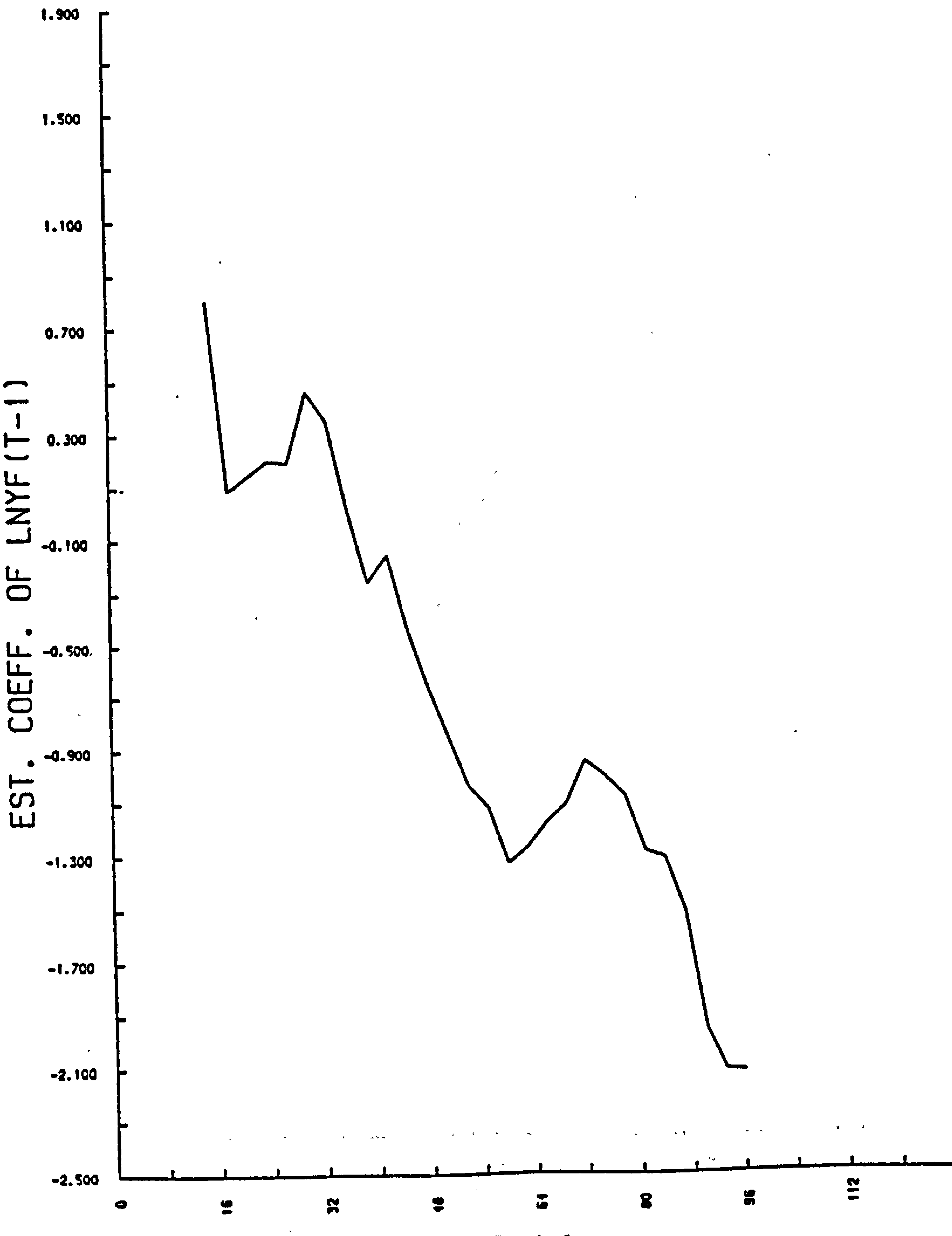
Graph 6SF: Variation in the Estimation in the Coefficient of $\ln Y_{t-1}$ Over Time



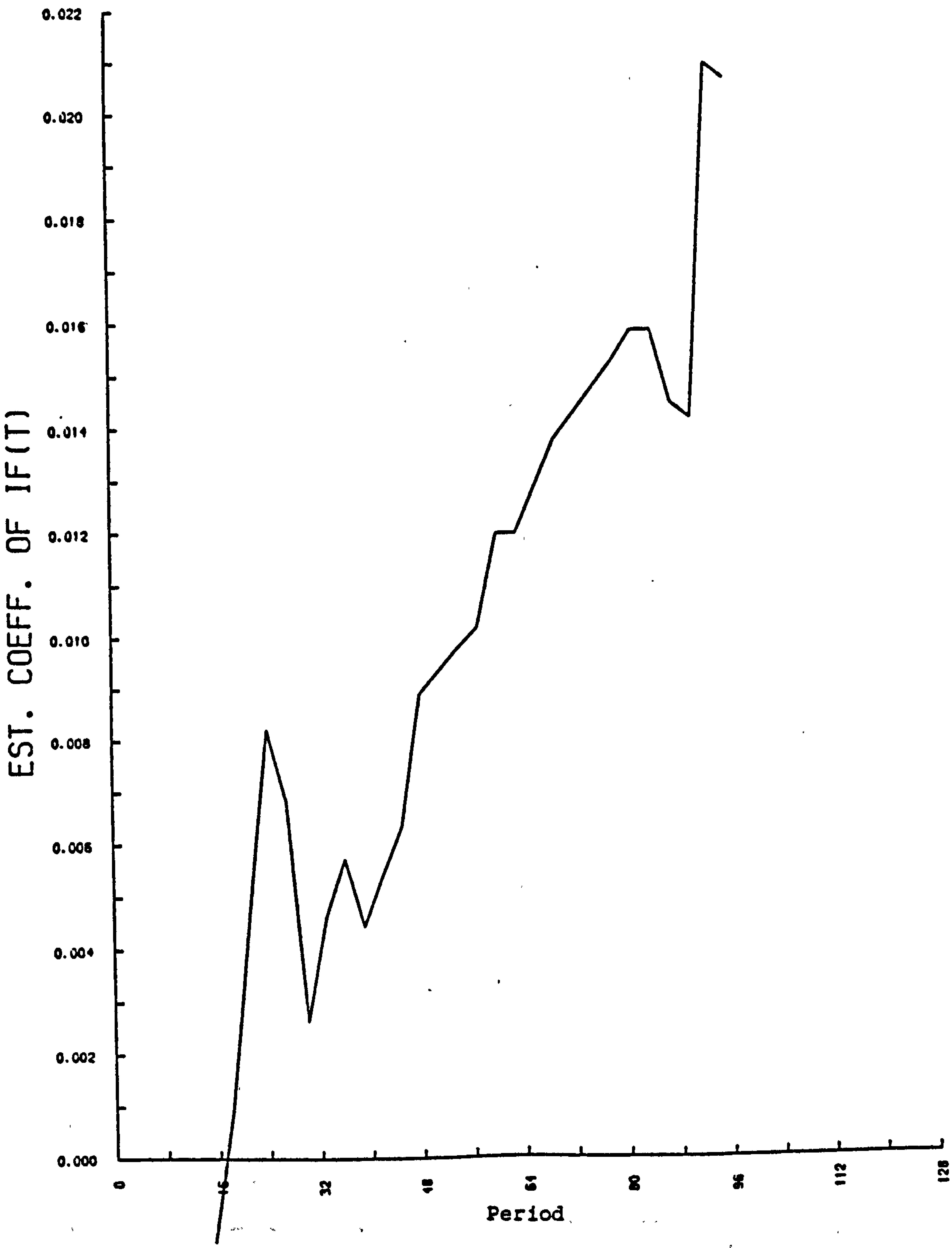
Graph 7SF: Variation in the Estimation of the Coefficient of $\ln Y_{f,t}$ Over Time



Graph 8SF: Variation in the Estimation of the Coefficient of $\ln Y_{f,t-1}$ Over Time



Graph 9SF: Variation in the Estimation of the Coefficient of $i_{f,t}$ Over Time



Graph 10SF: Variation in the Estimation of the Coefficient of $i_{f,t-1}$ Over Time

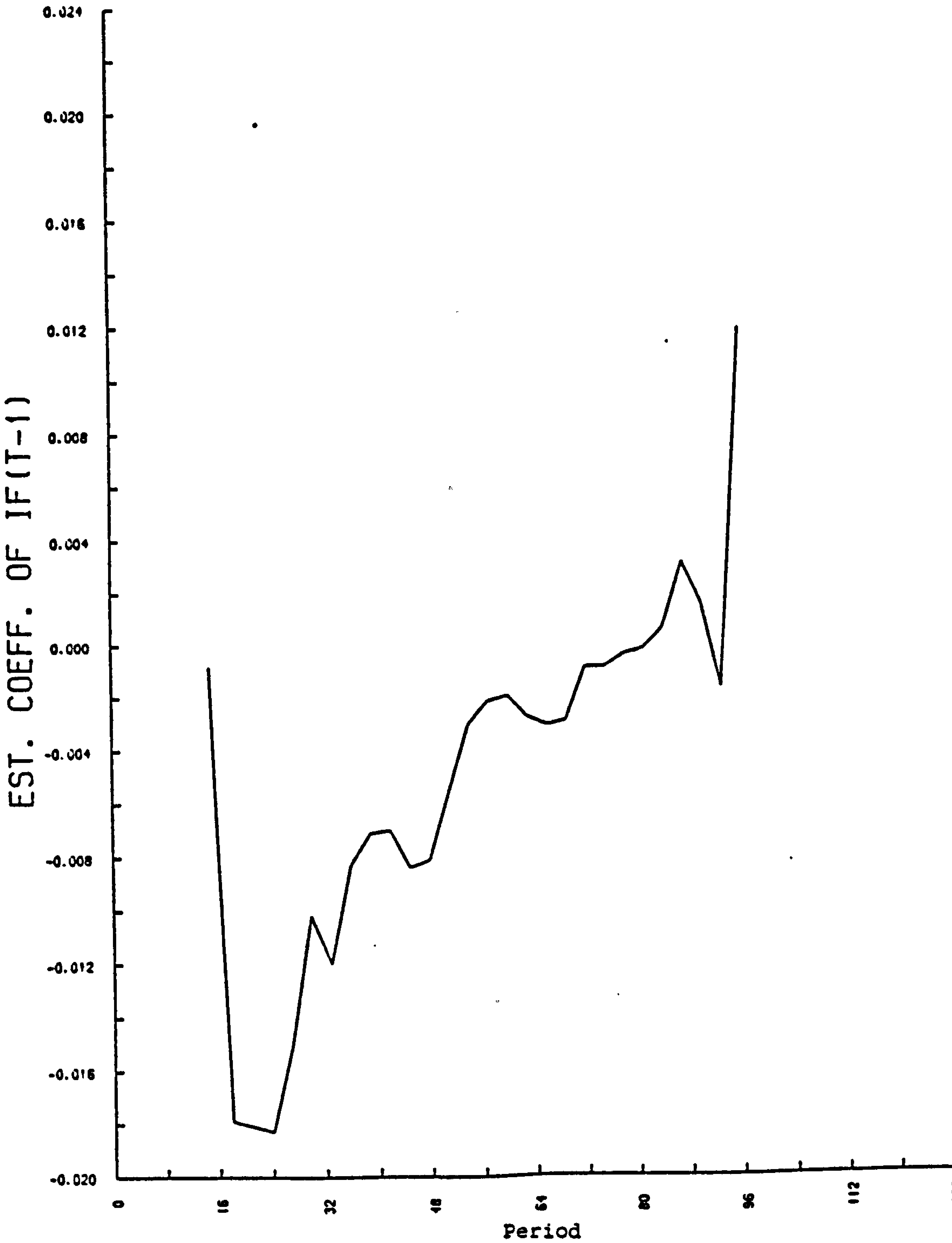


TABLE 4SF

FIRST OBSERV. OF ESTIMATION PERIOD (f)	LAST OBS. OF EST. PERIOD (L)	m= 1+L-f	NUMBER OF ADDITIONAL OBS. TEST FOR CONFORMITY WITH FIRST M OBSERVATIONS (n)	CALCULATED F-STATISTICS	CALCULATED MODIFIED F-STAT.	95% $F_{n,m-q}$ (q=d.f) CRIT. VALUE	$F_{n,n+m-q}$ 95% CRIT. VALUE
2	50	49	2	9.15	6.50	$F_{2,40}=3.23$	$F_{2,60}=3.15$
52	90	39	3	7.41	4.57	$F_{3,40}=2.84$	$F_{3,60}=2.76$

explanation). Table 4SF contains the evidence of the existence of structural breaks identified using the local F-test.

All of the calculated F-statistics--modified and otherwise--reported are significant meaning that, in Briscoe and Robert's terminology, there is strong evidence of structural breaks near observations 50 (February 1976) and 90 (June 1979). The break near observation 90 is thus the only one to be identified in estimations of the monetary, Dornbusch, and modified stock/flow models. As mentioned previously, this break coincides with the Thatcher Governments 1979 repeal of international capital flow restrictions. The break near observation 50 was only found in the estimations of the Dornbusch and modified stock/flow models. This break in early 1976 identifies a time when restrictions on international capital flows--on sterling loans related to Third World country trade, for instance--were being imposed.

F. Investigation of the Sensitivity of the Estimation to the Money Supply Measure Used

The sensitivity of the estimation of the modified stock/flow with monthly data to the money supply measure used was studied using the same procedures used in section V.E. of the previous two chapters. The regression reported in table SF3. was reestimated twice, first using UK M3 data for M, and then again, using M1 data for M. The results are presented in table SF5 for qualitative comparison.

Qualitatively, it appears that the estimation is sensitive to the money supply measure used. Support for this conclusion comes from table SF6 which reports the results of the J-tests comparing the three estimations. Presented in the table are the t-statistics of the

TABLE 5SF

Variable	Coeff's.(t-stat) Original Data (M=Stg M3)		Coeff's(t-stat) M=M3		Coeff's.(t-stat) M=M1	
C	5.024	(4.77)	3.734	(4.13)	3.324	(2.32)
$\ln M_t$	0.429	(0.905)	-0.212	(0 553)	0.550	(1.30)
$\ln M_{t-1}$	-1.613	(3.39)	-1.035	(2.72)	0.003	(0.007)
$\ln P_{f,t}$	2.789	(5.23)	3.119	(7.09)	-0.263	(0.557)
$\ln P_{t-1}$	-1.068	(4.25)	-1.149	(5.50)	-0 628	(1.96)
$\ln Y_t$	0.013	(0.062)	0.116	(0.648)	-0.190	(0.704)
$\ln Y_{t-1}$	0.321	(1.52)	0.390	(2.17)	0.005	(0.017)
$\ln Y_{f,t}$	1.589	(2.88)	1.410	(3.06)	-0.145	(0.204)
$\ln Y_{f,t-1}$	-2.142	(3.88)	-1.936	(4.18)	-0.750	(1.06)
$i_{f,t}$	0.020	(3.93)	0.167	(3.82)	0.023	(3.45)
$i_{f,t-1}$	0.002	(0.318)	0.196	(0.397)	0.003	(0.363)
	$\bar{R}^2$=.933, se=.040		$\bar{R}^2$=.952, se=.033		$\bar{R}^2$=.892, se=.050	
	DW=0.684, LLF=180.44		DW=0.730, LLF=197.06		DW=.305, LLF=147.69	

coefficients of the alternative hypothesis variables (see section V.E. of the monetary chapter for explanation of the J-test).

TABLE 6SF

		H_1		
		Stg M3	M3	M1
	Stg M3	X	10.13	4.73
H_o	M3	4.87	X	3.77
	M1	9.22	11.65	X

Compared to the 99% t-statistic critical value for n=60 of 2.39, each of the values in table 6SF is significant. Thus, it must be concluded that the estimation is sensitive to the money supply measure used.

G. Investigation of the Sensitivity of the Estimation to the Price Level Measure Used

The regression reported in table 3SF was reestimated twice more using export price (XP) data and unit labor cost (ULC) data for P in an attempt to study the sensitivity of the estimation to the price level measure used. The three estimations are presented in table 7SF for comparison.

Examination of the estimations reported in table 7SF lead one to the qualitative conclusion that the regression is sensitive to the price level measure used. Again, this conclusion is supported by the results of the J-tests comparing the three estimations as reported in table 8SF. The figures reported are, as usual, the t-statistics of the coefficients of the alternative hypothesis variables.

TABLE 7SF

Variable	Coeff's. (t-stat) Original Data (P=CPI)		Coeff's(t-stat) P=XP		Coeff's. (t-stat) P=ULC	
C	5.024	(4.77)	7.437	(12.86)	7.846	(10.22)
$\ln M_t$	0.429	(0.905)	-0.157	(0.385)	0.414	(0.813)
$\ln M_{t-1}$	-1.613	(3.39)	-0.294	(0.711)	-1.446	(2.83)
$\ln P_{f,t}$	2.789	(5.23)	-1.107	(4.20)	1.773	(3.26)
$\ln P_{t-1}$	-1.068	(4.25)	0.701	(7 58)	-0.509	(2.22)
$\ln Y_t$	0.013	(0.062)	-0.080	(0.444)	0.065	(0.289)
$\ln Y_{t-1}$	0.321	(1.52)	-0.073	(0.399)	0.171	(0.751)
$\ln Y_{f,t}$	1.589	(2.88)	0.074	(0.181)	0.700	(1.33)
$\ln Y_{f,t-1}$	-2.142	(3.88)	-0.186	(0.405)	-1.668	(2.89)
$i_{f,t}$	0.020	(3.93)	0.008	(1.67)	0 017	(2.99)
$i_{f,t-1}$	0.002	(0.318)	0.007	(1.55)	0.013	(2.33)
	$\bar{R}^2$=.933, se=.040		$\bar{R}^2$=.951, se=.034		$\bar{R}^2$=.923, se=.043	
	DW=0.684, LLF=180.44		DW=0.511, LLF=196.00		DW=.512, LLF=173.90	

TABLE 8SF

		H_1		
		CPI	XP	ULC
	CPI	X	8.17	0.450
H_0	XP	5.01	X	4.06
	ULC	3.54	8.66	X

All but one of the values reported in the table 8SF is significant at the 99% level (n=60 cv is 2.39) -- the exception not being significant at even the 75% level (n=60 cv is .679). The five significant t-stats provide sufficient evidence, however, that the estimation is sensitive to the price level measure used.

V. Conclusions

In summing up, it is important to remember that a modified version of the stock/flow model developed in section II was used in most of the empirical work. This approximation, allowing monthly data to be used instead of quarterly data (by dropping out the capital stock terms, for which monthly data do not exist for the UK), was judged acceptable on the basis of studies using quarterly data, which showed very small and statistically insignificant coefficients of the variables dropped out, as well as a statistically insignificant difference between an estimation including the capital stock variables and an estimation excluding those variables. Any conclusions drawn on the basis of studies using monthly data and this modified stock/flow model are applicable to the stock/flow model only to the extent that this approximation is reasonable, and more importantly, that it is transferable from the quarterly data case, where statistical support for it was generated, to the monthly data case, where it was used.

The major conclusion of the previous two chapters, that the model in question was dynamically misspecified, is a less clear cut matter in the present case. Testing the common factor hypothesis with the "base" data set on the modified model, using either quarterly or monthly data, or on the non-modified model, using quarterly data, provides no evidence that the model is dynamically misspecified. This conclusion was shown to be data dependent, however, since the use of different (but arguably appropriate) money supply measures and price level measures in the framework of the modified model and monthly data provides evidence that the model is misspecified. Thus, the matter of misspecification must be left up in the air.

Other conclusions are as follows:

1) As already mentioned, on the basis of a quarterly data study, capital stocks do not play a significant role in explaining exchange rate movements.
2) There is some difference between estimated coefficients and their a priori predicted values or signs.
3) On the basis of tests using quarterly data the stock/flow and modified stock/flow models are seen to be significantly better at explaining exchange rate movements than the monetary model, while the Dornbusch model is not significantly better. Also on the basis of studies using quarterly data, there is no evidence that the stock/flow model is significantly better than the Dornbusch or modified stock/flow models while the modified stock/flow model is significantly better than the Dornbusch model at the 90% level.

   On the basis of studies using monthly data, the modified stock/flow model was seen to be significantly better at explaining exchange rate movements than the Dornbusch model, but not significantly better than the monetary model.
4) Structural breaks were identified near observations 50 (February, 1976), and 90 (June, 1979).
5) The estimation was shown to be sensitive to the money supply measure used.
6) The estimation was shown to be sensitive to the price level measure used.

In the next chapter we leave empirics behind and discuss the theoretical plausibility of one possible extension to the monetary, Dornbusch and stock/flow models, namely, sophistication of the expectation formation equation.

The Dynamics of Rational Expectations Models

I. Introduction

In the past three chapters we studied three empirical models of increasing dynamic sophistication, each of which is commonly used or built on in the recent literature on exchange rate determination. All three models showed signs of dynamic misspecification*--signs that they fail to capture all of the dynamics critical to the behaviour of the exchange rate under study. Thus we have produced evidence that none of the models studied here is the "true" model--that none of them accurately explains movements in the exchange rate. Having rejected these models, the next logical step is to return to the theory in search of a model that is dynamically and otherwise more sophisticated. Unfortunately, the most widely used extension (rational expectations) of what is arguably the most important and widely studied component (expectations formation) of exchange rate modelling has some exceptionally unattractive theoretical characteristics--theoretical shortcomings that are much more problematic than any of those encountered in the three models already studied. As a result, this chapter breaks from the largely positive approach of the last three chapters and instead focusses on the theoretical implausibility of rational expectations models as they are usually formulated. This discussion therefore points to pitfalls that should be avoided in future attempts at modelling using rational expectations. In this chapter we will turn away from empirics and consider how to develop a model that is more dynamically sophisticated than those three models already studied. If empirics should be the cutting edge of inquiry, then theory needs to provide the material to be cut: the present chapter considers some such material.

The expectation formation assumption seems an obvious aspect to consider as a candidate for increased sophistication. Both the Dornbusch and the stock/flow models assume regressive expectations, a mechanism also discussed in the review of the literature chapter. Agents are assumed to calculate the long run steady state exchange rate implied by the state of the economies at any given point in time, using data available at the time of calculation. Agents then bid up or offer down the exchange rate to move it towards the long term rate. Partial adjustment of the exchange rate to the long run rate injects the possibility of systematic errors in expectations formation. This possibility is at odds with empirical work cited in the review of the literature chapter that indicates foreign exchange markets are efficient.

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*The conclusion that the stock/flow model was dynamically misspecified was dependent on the money supply and price level measure used.

Also mentioned in the review of the literature chapter, the rational expectations hypothesis seems an attractive alternative. This hypothesis simply states that individuals do not make systematic forecasting errors--that they use all information available (including past data, announcements and rumors of governmental policy changes and other indicators of future events) in forming expectations. They therefore err only because of stochastic disturbances, resulting in an error term with mean of zero and no autocorrelation.

Unfortunately, users of the rational expectations hypothesis in exchange rate (and other) modelling usually go too far. While it may be reasonable to assume that on average agents correctly calculate the effects of political, economic and sociological changes on the exchange rate, it seems unlikely that agents believe or behave as if they believe that their expectations will always be fulfilled.

In the simple linear model

$$a = xb + yc + u,$$

where u is a white noise error term, it is true that*

$$a^e = xb^e + yc^e + u^e = xb^e + yc^e$$

where superscript e denotes the expected value of the given term. Because u is a white noise error term, the best estimate of it any any point in time is zero. This is simply the idea of Certainty Equivalence--that, in Beggs words (82, pp.51-2),

> "The solution of a stochastic model differs from the solution of a deterministic or non-random model only in the trivial respect that actual values of future variables are replaced by current expectations of these future

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*whereas it is not true for nonlinear models such as $a=xb/yc+u$ that $a^e=xb^e/yc^e+u^e$

> variables..." if the model "is linear and contains an additive random disturbance with mean zero."

Nevertheless, if agents realize that there exists a finite probability that in fact u will not be zero, they may, instead of behaving as if they were certain that u will equal zero, somehow try to hedge or insure against the possibility that u will not equal zero.

In section II I present a representative rational expectations model that includes the problems discussed above and displays saddlepoint type stability. In section III I discuss arguments against the realism of this type of model, focussing on the saddlepoint/jump variable formulation. In section IV I consider the concept of structural stability and its consequences in terms of the relative desirability of various stability types.

II. A Representative Rational Expectations Model of Exchange Rate Determination

Buiter and Miller (81), hereafter B&M, have developed a rational expectations model of exchange rate determination that displays saddlepoint type stability. Their model is presented here because it is representative of rational expectations models in the literature and because B&M focus on the dynamics of their model--dynamics being the main object of concern in this chapter.

B&M's model consists of the five equations:

1) $\ln M = k(\ln Y + \rho) - \lambda(i - i_d) + \ln P + \Theta; \; k, \lambda > 0$

2) $\ln Y = -\gamma(i - D\ln P) + \delta(\ln S - \ln P) + \chi\rho_\infty; \; \gamma, \delta > 0$

3) $D\ln P = \Phi \ln Y + \pi; \; \Phi > 0$

4) $\pi = \mu;$

5) $D\ln S = i - i_f - \tau.$

Equation 1 is a dressed up version of the money market equilibrium (LM) equation in which the supply of money is equal to the demand for money which depends on oil (ρ) and non-oil (Y) income, the net of interest paid on non-money assets (i) less the interest paid on money (i_d), the price level (P), and the rate of indirect tax (Θ). Likewise, the goods market equilibrium (IS) equation, 2, assumes that the supply of goods or real income (Y) is equal to the demand for goods which depends on the real rate of interest (D is the differential operator) the real exchange rate or relative price of domestic goods (S is the nominal exchange rate and is the domestic currency price of foreign currency), and the permanent income equivalent of oil production (ρ_∞). The hyperinflation accommodating character of the model, present in the use of real interest rates instead of nominal rates in the goods market equilibrium equation, is also apparent in the price adjustment explaining equation 3. This is a

Phillips curve with the core rate of inflation (π)--which is equal to the long run rate of growth of the money supply (μ) per equation 4--added in. Finally, equation 5 says that, in light of the assumptions that agents have rational expectations and perfect information (which added together mean perfect foresight), the common assumption that the expected yields of domestic and foreign assets will be equalized becomes the stronger assumption that actual asset yields will be equalized. Taxes on capital inflows or subsidies on capital outflows (τ) are also taken into account.

Of the three variables for which dynamic equations are specified, lnP, lnM, and lnS, the latter two are allowed to make discrete jumps at any given point in time while lnP cannot. lnM makes jumps as a result of unanticipated changes in the growth target of the monetary authority and lnS jumps whenever agents wish to jump it. With jumps in lnM taken as exogenous, this system is seen to contain one forward looking or jump variable, lnS.

A one time unanticipated rise in the money supply over and above the rise indicated by the long run rate of growth is immediately soaked up by a rise in income above the equilibrium "high employment" level (related to Friedman's natural rate) and a fall in net interest paid on non-money assets (which can involve a fall in i, a rise in i_d, or both). Prices, being sticky, cannot help take up the slack in the short run. But the above equilibrium level of real income puts pressure, via the Phillips curve, on prices, which eventually will adjust to let income return to its equilibrium level (by which time DlnP will have returned to its 'base line' level indicated by DlnM=μ) if the system is stable. Stability of the system depends, in part, on the extent to which a rise in income causes a rise in prices through the Phillips curve, and the extent to which the higher inflation rate causes a further rise in income by lowering real interest rates in equation 2. Meanwhile, that part of the monetary shock that was translated into lowering of domestic net non-money interest rates may, if some of it goes to i and not all to i_d (if all of the change in net non-money interest rates went to an increase in i_d then the rest of the model would be unaffected by this aspect of the monetary shock), result in appreciation of the domestic currency (through equation 5) which would, in turn, affect income via lower relative prices (in equation 2). Therefore stability also depends on the extent to which relative prices affect demand for domestic goods.

The question of stability is better dealt with when the system is in the form of B&M's two dynamic equations:

$$(6) \qquad DL = \frac{1}{\gamma(\varphi\lambda-k)-\lambda}[\varphi\gamma(L) + \varphi\lambda\delta(C) + A]$$

$$(7) \qquad DC = \frac{1}{\gamma(\varphi\lambda-k)-\lambda}[(L) + \delta(\varphi\lambda-k)(C) + B]$$

where the two new variables, liquidity (L) and competitiveness (C), are defined as $L=\ln M-\ln P$ and $C=\ln S-\ln P$, respectively. Formulation of the system's dynamic equations in these terms means that in the steady state the dynamic variables under study (L and C) will be constant. This would not have been the case if the reduced form dynamic equations had been formulated in terms of lnM, lnP and lnS, all of which are changing at constant rates (determined by the long run rate of growth of the money supply) in the steady state.

It is evident that the coefficients of L and C in equation 6 and the coefficient of L in equation 7 must all have the same sign, depending on the sign of the term in front of the parenthesis, which B&M call $1/\Delta$ and assume to be negative. The sign of the coefficient of C in equation 7, on the other hand, can be either positive or negative when the other three coefficients are negative (depending on whether $\phi\lambda \lessgtr k$--on whether or not $-\lambda$ played a crucial role in making the other three coefficients negative), although it must be positive if the other three signs are positive since $\phi k > k+\lambda$ implies $\phi k > k$.

For the graphical analysis that follows referencing will be made simpler if the two dynamic equations are restated in the short hand forms:

6a $\quad DL = eL + fC + A$

7a $\quad DC = gL + hC + B$

where $e=\frac{\varphi\gamma}{\gamma(\varphi\lambda-k)-\lambda}$, $f=\frac{\varphi\lambda\delta}{\gamma(\varphi\lambda-k)-\lambda}$, $g=\frac{1}{\gamma(\varphi\lambda-k)-\lambda}$,

and $h=\frac{\varphi\lambda-k}{\gamma(\varphi\lambda-k)-\lambda}$.

It appears that graphs of cases 1-5 (next page) present the five combinations of signs and magnitudes of the coefficients of L and C in equations 6a and 7a that may result.

It is easy to verify the stability types arrived at on the basis of these diagrams by resorting to the trace-determinant rules for the 2x2 case (using the matrix $\begin{bmatrix} e & f \\ g & h \end{bmatrix}$) as discussed in the review of the literature chapter ($T < 0$ and $D \geq 0$ means universal stability*; $T > 0$ and $D \geq 0$ means instability; and $D < 0$ means saddlepoint stability). In cases 1 and 2 the trace must be positive (since both e and h are positive) while in cases 3 and 4 the trace must be negative (since both e and h are negative). Cases 1 and 3 have positive determinants and cases 2, 4, and 5 have negative determinants, and the signs of determinants and traces are therefore as required for the type of stability graphically represented in each case.

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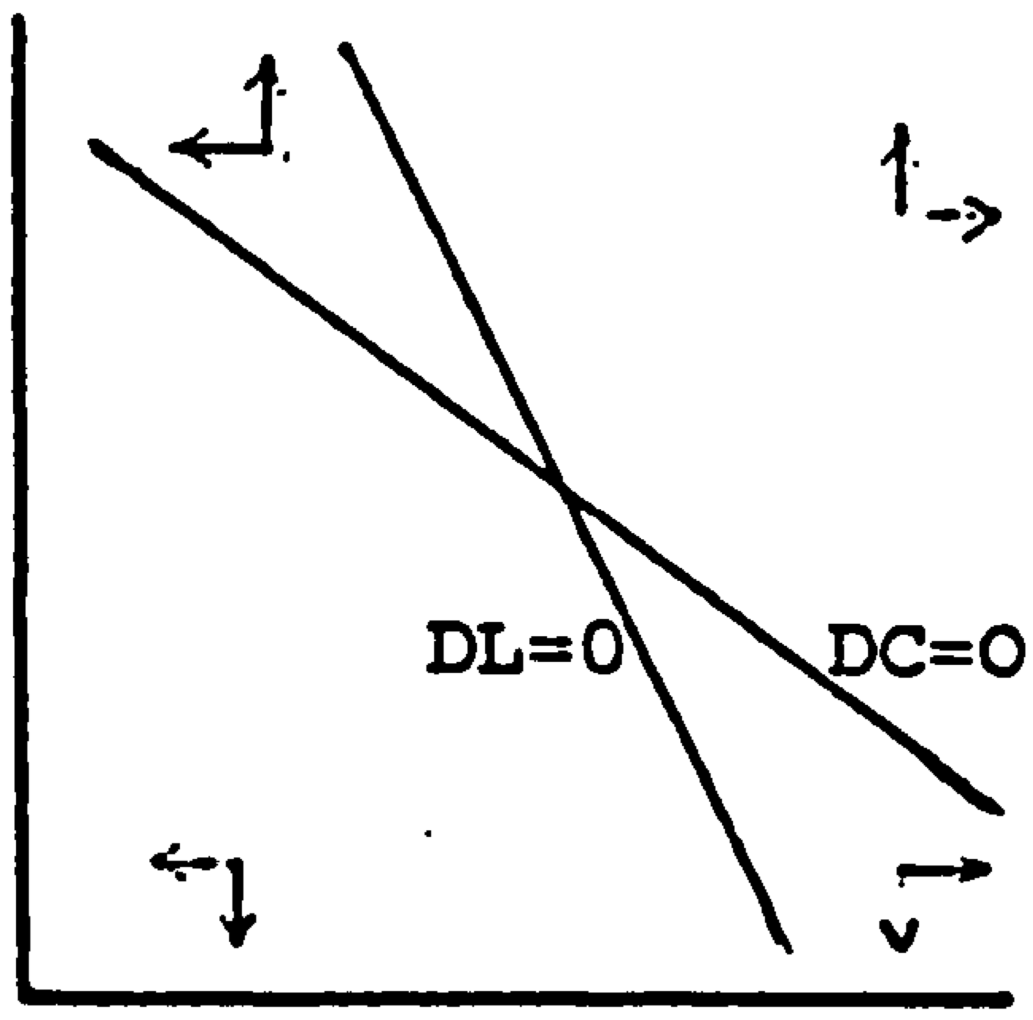
*As used here, universal stability has nothing to do with the idea of global stability, but refers to the case in which a model displays only convergent dynamic paths in the universe (which may be only local) under study.

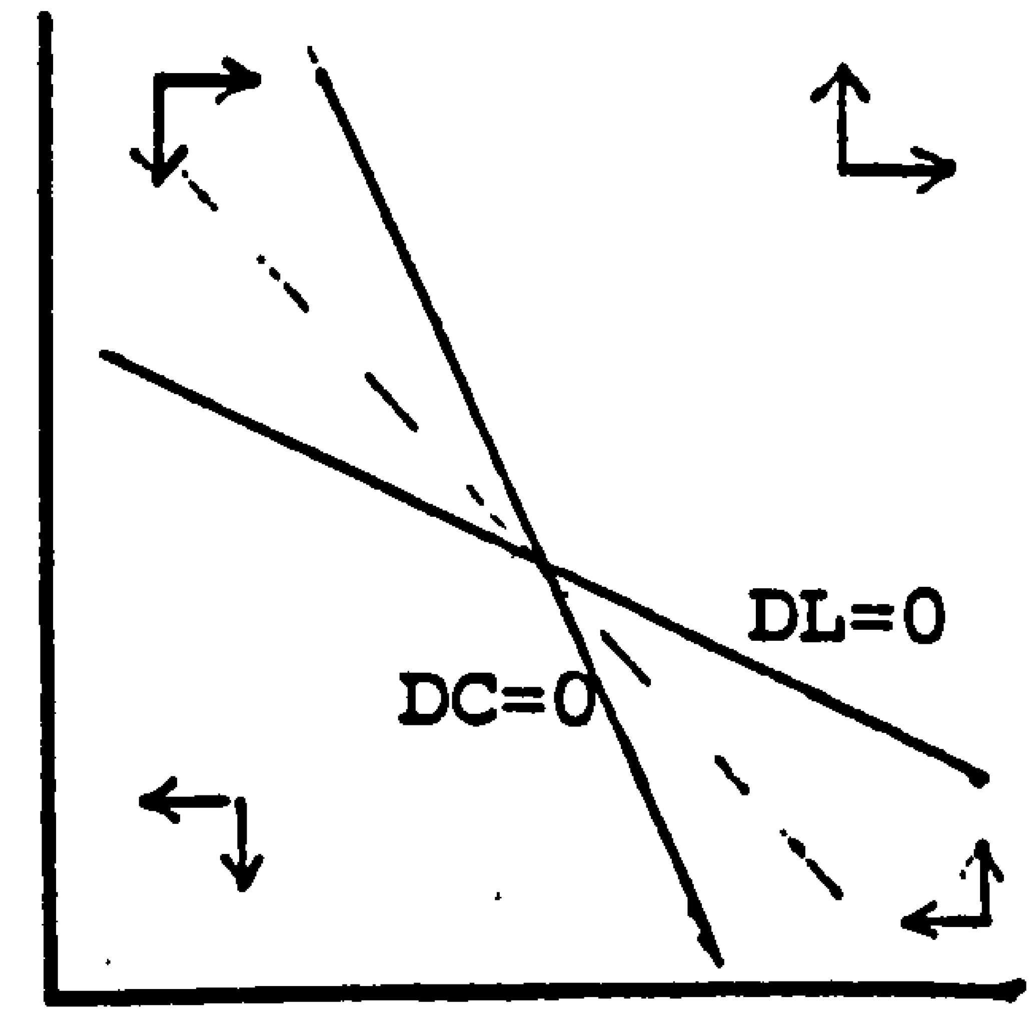
Case 1 (Unstable)

e,f,g,h>0,e/f>g/h



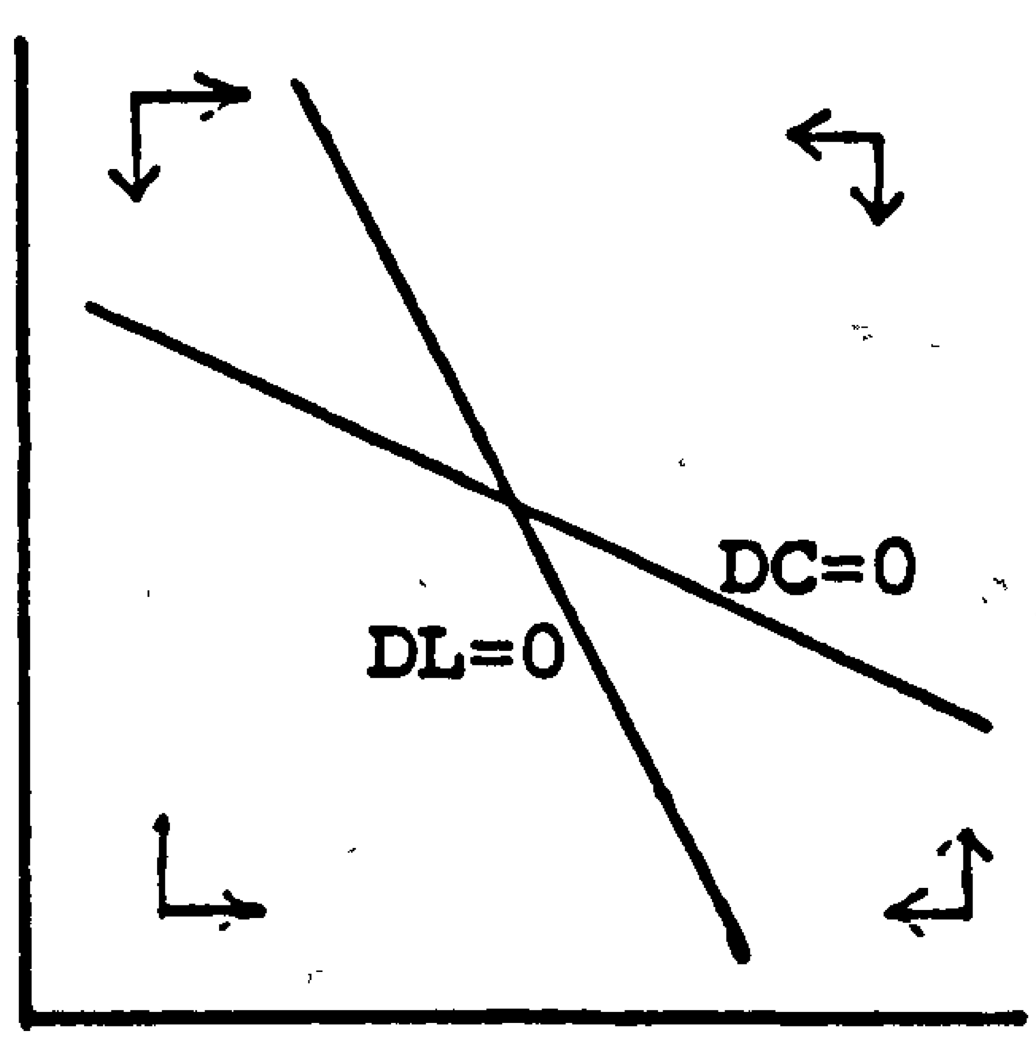
Case 2 (Saddlepoint)

e,f,g,h>0, e/f<g/h



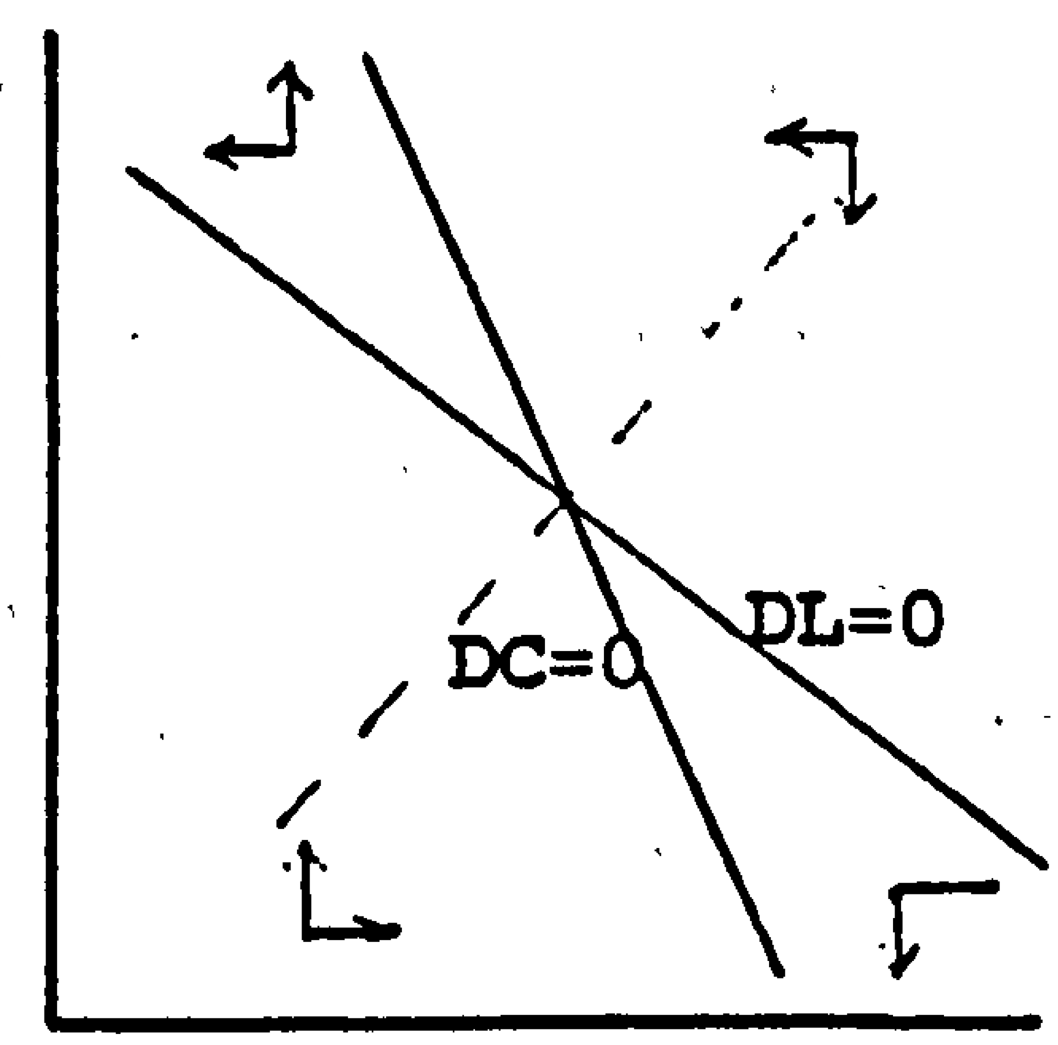
Case 3 (Stable)

e,f,g,h<0, e/f>g/h



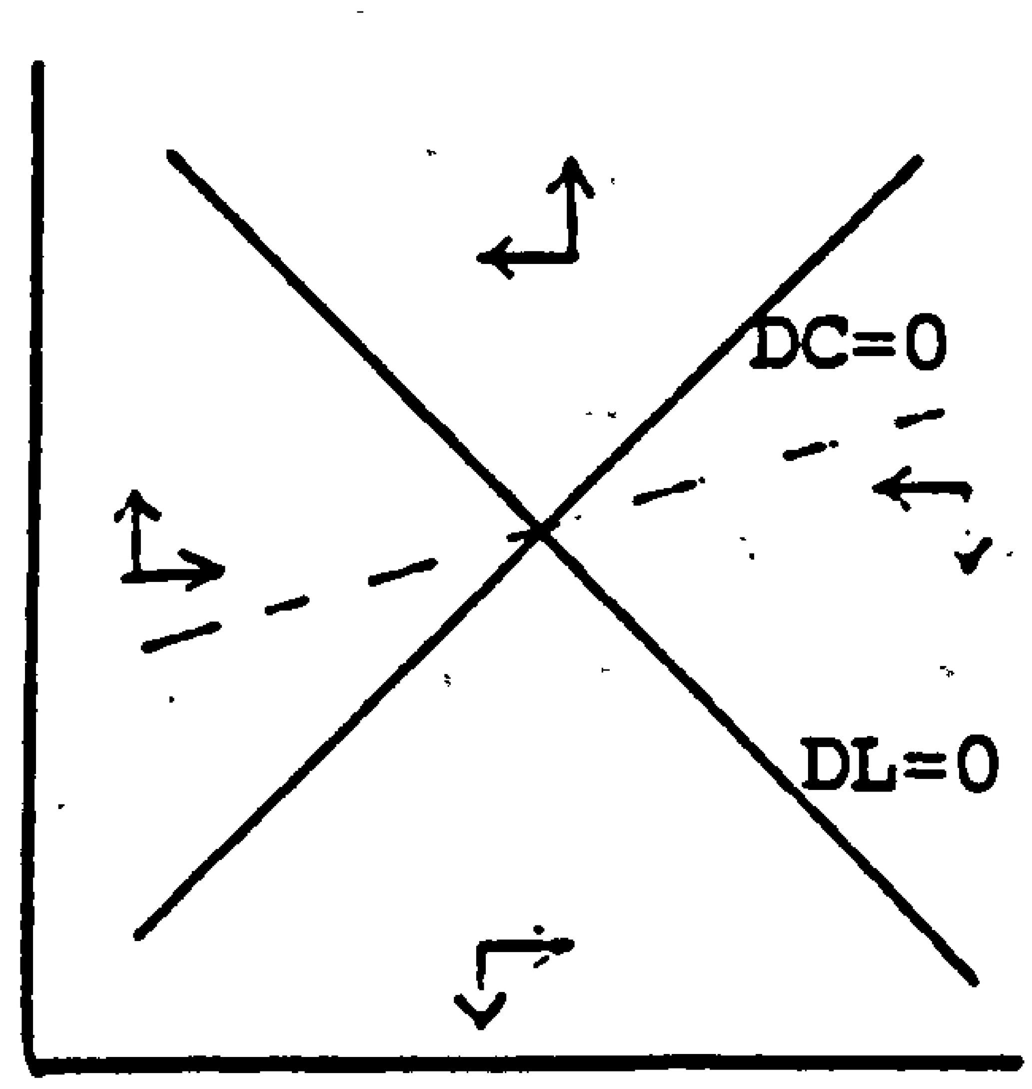
Case 4 (Saddlepoint)

e,f,g,h<0, e/f<g/h



Case 5 (Saddlepoint)

e,f,g<0, h>0



Case 1 has positive trace and determinant and represents an unstable system--anytime the economy is not in equilibrium (which is unique in the universe under study since the system is linear) it will respond with further moves away from the equilibrium. This case is not very interesting economically except when this system is a linearised version of a nonlinear model, in which case the system may be only locally unstable (as indicated by the linear part of the model) but globally stable if, for example, it is a limit cycle model.

Case 3 has a negative trace and positive determinant and therefore represents a universally stable system--anytime the economy is not in equilibrium, it will be on one of the infinite convergent paths, insuring that, in time, equilibrium will be obtained. In general, this type of stability might be desirable in a model of economic (or natural) phenomena. But as discussed in the review of the literature, universal stability can present difficulties in a model with one or more jump variables (the exchange rates, and therefore the value of competitiveness, C, are allowed to make discrete jumps in B & M's model--jumps that are determined by the expectations of agents). One of the infinite convergent paths will be chosen as the unique solution path only if the correct number of boundary conditions is defined. Unless a unique solution path exists, agents will be unable to determine where to move the jump variable. In B & M's model the initial value of L (which is unable to jump) provides one of the necessary boundary conditions, but the auxiliary assumption that the transversality condition holds is required to provide the other.

Cases 2, 4 and 5 have negative determinants and so represent systems with saddlepoint type stability. The saddlepoint model displays a unique convergent path (indicated by the dotted lines in the three diagrams). Anytime the economy is at a point not on that path it will move further away from the equilibrium.

In this case the transversality condition is required, not only to supply the additional boundary condition so that a unique solution path is specified, but also to insure that the economy will not follow an explosive path (which is not possible in the universally stable case).

All five of the above cases were presented and discussed here so that all three of the basic stability types (neglecting non-convergent type stability) could be shown as they can occur in the literature. It is possible to prove*, however, that in the case of B & M's model, the term outside the parenthesis in equations 6 and 7 (the inverse of B & M's Δ) will have the same sign as the determinant of the matrix $\begin{bmatrix} e & f \\ g & h \end{bmatrix}$ and the trace of that matrix will be positive if Δ is positive. This removes case 2 (which has positive trace and negative determinant) and case 3 (which has negative trace and positive determinant) as well as some of case 5 (when $h > -e$, making the trace positive and the determinant negative) leaving the three cases 1,4 and 5--which are the three presented by B & M as possible. As already mentioned B & M also assume that Δ is negative, removing case 1 as a possibility.

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* This proof was shown to me by Simon Clark:

$\Delta = \gamma(\varphi\lambda - k) - \lambda$. If $\Delta < 0$, then $\gamma(\varphi\lambda - k) < \lambda$; if $\Delta > 0$, then $\gamma(\varphi\lambda - k) > \lambda > 0$.

$\det\begin{bmatrix} e & f \\ g & h \end{bmatrix} = \frac{1}{\Delta^2}[\delta\varphi\gamma(\varphi\lambda - k) - \varphi\lambda\delta]$. If $\det < 0$, then $\delta\varphi\gamma(\varphi\lambda - k) < \varphi\lambda\delta$, or $\gamma(\varphi\lambda - k) < \lambda$; if $\det > 0$, then $\delta\varphi\gamma(\varphi\lambda - k) > \varphi\lambda\delta > 0$, or $\gamma(\varphi\lambda - k) > 0$.

$\mathrm{trace}\begin{bmatrix} e & f \\ g & h \end{bmatrix} = \frac{1}{\Delta}[\varphi\gamma + \delta(\varphi\lambda - k)]$. If $\Delta > 0$, then $(\varphi\lambda - k) > 0$ and $\mathrm{trace} > 0$.

III. The Realism of Saddlepoint Models and the Jump Variable Mechanism for Achieving Equilibrium

In the last section I presented a perfect foresight model that exhibited saddlepoint type stability. Several assumptions are used to make saddlepoint stability a feasible stability type. If, when the economy is not in equilibrium economic agents are to use the jump variable* to place the system on the unique stable branch, they must A) be able to correctly and accurately calculate the location of the system's equilibrium point and stable branch, B) all agree that they want to use the jump variable to place the economy on the stable branch, C) be able to use the jump variable accurately to jump precisely to the stable path, and, D) believe, or rather, act as if they believe, that the first three conditions will be met. As was mentioned there, the model presented in the last section is representative of rational expectations models to be found in the literature. Saddlepoint type stability with jump variables dominates such models and so the four above assumptions are common components of rational expectations modelling.** As such, it seems worthwhile to examine the realism of these four assumptions--which really boil down to the realism

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*In this discussion it is assumed that some underlying economic mechanism exists which allows one of the dynamic variables to behave as a jump variable. It is also assumed that there exist the number of jump variables required to allow agents to jump the economy to the stable branch (calculation of the number of jump variables required is discussed in the review of the literature chapter). B&M's model, on which this discussion is based, fulfills these two conditions.

**Even when perfect expectations are not assumed as in B&M, the concept of Certainty Equivalence (see Begg 82, p.52) allows those using the rational expectations hypothesis to formulate models very similar to B&Ms.

of the saddlepoint/jump variable mechanisms***--that are so integral to most rational expectations models. Such an examination is undertaken in the four subsections that follow.

A. Agents are Able to Accurately Calculate the Location of the System's Equilibrium Point and Stable Branch

As the first step in their use of the jump variable to attain equilibrium, agents must be able to accurately calculate the location of the system's equilibrium point and unique stable path to that equilibrium.

If, as in the case of B & M's model, theory leaves agents with more than one basic graphical representation of the system (agents are left with cases 4 and 5 as possibilities in B & M's model), agents must somehow be able to choose which of those representations is relevant for the situation they are trying to understand and accurately solve the relevant equations to find the unique stable branch and equilibrium. This requires that agents have accurately calculated the mean values of the coefficients in the model so that they can determine the relative positions of the locii on which the dynamic variables are constant.

There are several problems that must be dealt with if agents are to accurately solve the relevant equations to find the stable branch and equilibrium. First, expectations must be perfect not only in the short run, but over all time because the system will take an infinite period of time to reach equilibrium via the stable branch. This is a long ways from the original statement of the rational expectations hypothesis that

***For more discussion on the plausibility of jump variables, see George and Oxley (85).

agents do not make systematic errors. Perfect foresight over all time requires that agents can correctly calculate the time paths of all of the variables in the model over all time--a difficult task in the deterministic world of B & M's model, but almost certainly an impossibility in the real world. For stochastic models to which the concept of certainty equivalence has been applied, the dropped error term will still have zero expected mean, but may have a very large variance.

Second, agents must not only not expect any future stochastic shocks to the system, but they must actually expect that there will not be any future exogenous shocks--and the actual occurrence of such shocks must be very infrequent. Otherwise, agents might begin to think that the equilibria, the locations of which they are calculating after each shock to the system, will never be reached before a new shock occurs and they might begin to diversify and do other things associated with lack of confidence that their expectations were perfect. Models such as B & M's that use the saddlepoint/jump variable formulation may therefore not really be applicable to a world (like the one we live in) in which shocks to the economic system are a reasonably common part of every day life.

Third, if a shock to the system takes the form of an announcement of a change in policy by government or monetary authorities, agents must accurately determine the credibility of the government with respect to this policy change.* This credibility is divided into two parts: The extent to which the authority making the announcement is honestly going to pursue the new policy objective, and the capability of the authority in pursuing that objective. Agents must accurately assess this

*Studies of this credibility factor can be found in Backus and Driffill (85) and Barro and Gordon (83 JPE) and 83 (JME).

credibility and on the basis of that assessment calculate new time paths for all of the variables in the model (and new coefficients if the coefficients will be changed by the policy change). If agents inaccurately assess the credibility of the authority with respect to the policy change, the realization of inaccurate assessment, when that realization occurs, will result in a second shock to the system.

Finally, it must be remembered that some shocks to the system may result in shifts in the locii on which the dynamic variables are constant, meaning that a new equilibrium may exist and the old one will no longer be relevant. In such cases it is not good enough for agents to know where the old equilibrium and stable branch were located, they will actually need to be able to calculate the new locations of these phenomena.

B. Agents Must All Agree that They Want to Use the Jump Variable to Place the Economy on the Stable Branch

If, in spite of the problems discussed in the preceding subsection, agents are able to correctly calculate the location of the system's equilibrium and stable branch, then the next step (in making saddlepoint type models with jump variables a feasible stability type) is that all agents must agree that they want to use the jump variable to move the economy to the stable branch.

Users of saddlepoint-jump variable type models commonly simply assume that this condition will be met though such an assumption is not part of the rational expectations hypothesis and therefore must be considered an appendage. B & M (p. 151), for instance, state that,

> "the assumption of long-run and short-run perfect foresight and the transversality condition that rational agents will not choose an unstable solution mean that the jump variables will always assume the value required to put the system on the unique convergent solution trajectory."

But Gray and Turnovsky (79, p. 650) discuss transversality conditions, saying,

> "These state that only solutions satisfying certain terminal conditions represent optimising behaviour. The effect of imposing these conditions is typically to force the system onto the stable arm of the saddle, thereby insuring stability of the resulting dynamic system."

Yet, as George and Oxley have pointed out, "Satisfaction of some transversality condition cannot, in general, be considered a necessary condition for an optimum."

In any case, imposition of transversality conditions is simply an around about way of assuming that the jump variables will be used to place the system on the stable branch. Begg (82, p. 64) is more blunt on the issue:

> "As Keynes emphasised, the economy must be dominated by long-sighted speculators if such pressures (to place the system on a path other than the stable one--parenthesis added) are to be resisted and it is at least arguable whether this is the case."

Unfortunately, it is also arguable that this is not the case. There are several reasons that agents might choose to place the system on one of the unstable branches, if only for a finite period of time.

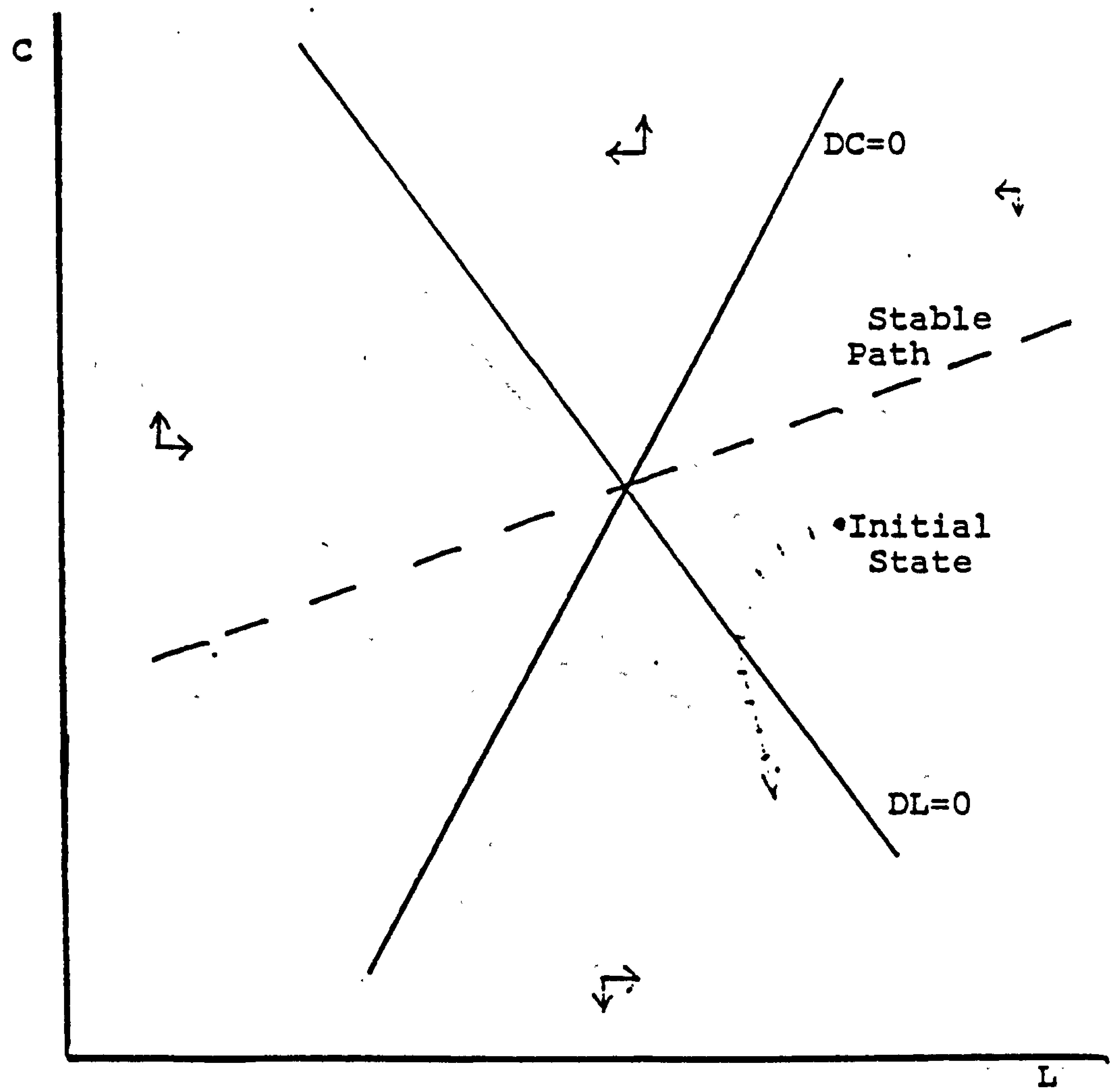
Before discussing these, however, it is necessary to clear up the idea that saddlepoint models display only one path to equilibrium. In fact, even if agents are allowed to make only one jump with the jump variable in response to a shock (which there is no reason to assume), and assuming that as a result of the shock the economy does not just happen to land on the stable branch, there are an infinite number of paths, as shown in Diagram S1, that could be chosen to return the economy to equilibrium.

The path that is nearly always assumed in saddlepoint type models is that resulting from an immediate jump in the jump variable to place the economy on the stable path. It is possible, however, for any one of a number of reasons discussed below (B & M, p.156 discuss another reason), that agents may deem it in their best interests to wait to jump the economy to the stable branch or equilibrium until a later date. Thus even if we assume that agents do want to return the economy to equilibrium eventually, they still have an infinite number of paths to choose from in fulfilling that objective (and this is assuming they are allowed only one jump in response to any given shock which there is really no reason to assume.) Unless each agent assumes--and is correct in assuming--that all other agents will choose the same path as himself, he will find that, requoting the words of Begg (p. 36) on the universal stability case, "expectations formation will prove extremely difficult" and saddlepoint type stability will offer no advantages over universal stability.

There are several reasons agents might not want to jump the economy to the stable branch immediately. It is usually assumed that agents are trying to maximize some utility function over time. In the infinite horizon case the stable branch may be an optimal solution because it leads to the equilibrium and only the equilibrium endpoint satisfies the transversality condition*. In the

*As mentioned above, however, the transversality condition is not in general a necessary condition for an optimum.

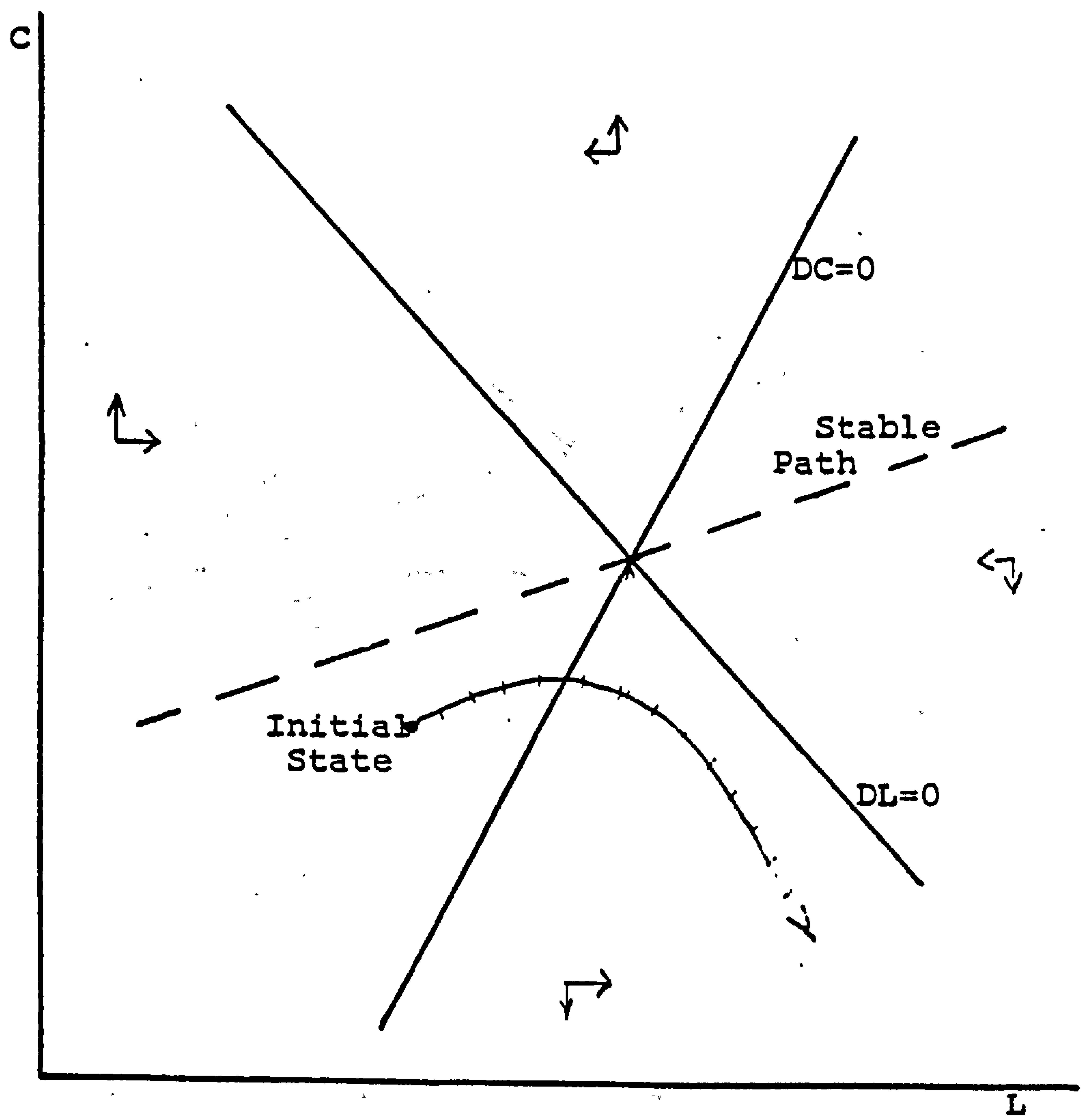
Diagram S1



Path followed if no jumps are executed

Possible jumps

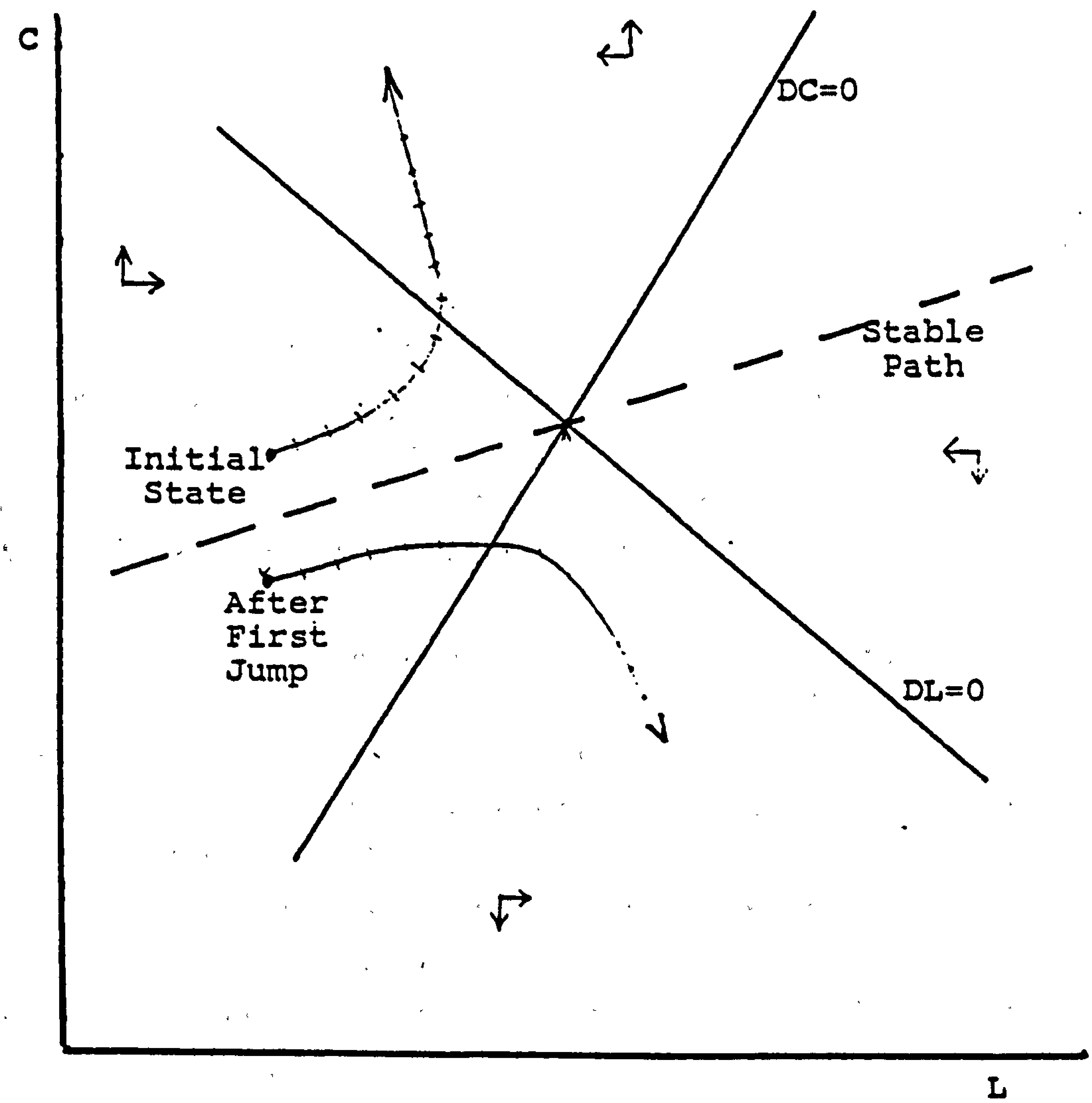
Diagram S2



Path followed if no jumps are executed

› Jump

Diagram S3



Path followed if jump is not executed

Jump

finite horizon case, on the other hand when agents are looking at the short term advantages of one path or another without worrying about the long term (possibly explosive) behaviour of the economy along that path the stable branch generally will not be an optimal solution path. Thus, agents might be able to reap the short run benefits obtained by following a non-stable path for some finite period of time and then jump the economy to the stable branch, thereby still taking advantage of the long term optimality of the stable branch. For more discussion of these ideas see George and Oxley (1983, pp. 6-11).

It is possible that in addition to optimizing some utility function, agents have other constraints that might make them want to jump the economy to the stable branch of equilibrium later rather than sooner. For instance, agents may not be satisfied with a solution path that requires an infinite length of time to reach equilibrium (which the stable branch does because it moves the system more slowly the closer it gets to equilibrium). As indicated in Diagram S2, it may be possible for agents to choose a solution path containing only one jump that returns the economy to equilibrium in finite time. Suppose, in response to a shock which perturbs the economy away from equilibrium, agents decide, for the time being, to leave the system on the explosive path landed on. As the economy moves along the path, short run optimisation may be achieved, as discussed above. At the moment along the path when L is equal to its equilibrium value, agents use the jump variable C to return the economy to equilibrium, thereby restoring equilibrium in finite time. This type of finite time solution may require more than one jump for some perturbations of the system as shown on S3. If in response to the perturbation shown, agents decide to leave the system on the explosive path landed on, they will never reach a point at which L is equal to its equilibrium value*. If, agents decide to make two or more jumps in response to the shock (there is no obvious reason why the number of planned jumps should be constrained) they will be able to use the first to jump to an explosive path that does have a point at which L is equal to its equilibrium value and the second to return the system to equilibrium in finite time.

Uneven distribution of information, though assumed away in B & M's model and virtually all rational expectations type models, is another reason the system might be allowed to follow an explosive path for some time before jumping to the stable path. Assume, for instance that all agents were able to calculate the location of equilibrium, but that one group of agents believed the system to be on the stable branch while the other group of agents correctly realized that the system was on an explosive path. The knowledgeable agents probably would not have the resources to jump the system to the stable branch. In any case, they would likely find it more profitable to guard their information and speculate using their informational advantage until the less informed agents realized that the system was on an explosive path.

C. Agents are Able to Use the Jump Variable to Accurately Jump the Economy to the Stable Path

Even if agents are able to accurately calculate the location of their system's equilibrium and stable branch, and they are able to agree on which of the infinite possible routes they will take, still they must be able

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*This assumes that Diagram S3 shows the global characteristics of the model. It is, of course, possible that Diagram S3 only shows the local characteristics of the model and that other equilibria exist globally.

to use the jump variable precisely to move the system to the point agreed upon if equilibrium is to be restored in a system displaying stability.

The main point here is that, like in subsection III.A., this task must be carried out with perfect accuracy. This should cause little difficulty if the jump variable is a price like the exchange rate or interest rate, which can simply be set at the correct level, but may cause more trouble if the jump variable is less easily manipulated. An infinitely small error in the magnitude of the jump will place the system not on the stable branch, but on one of the infinite explosive paths, requiring another jump at some future date if the system is to reach equilibrium. If many mistake related jumps (at which points the jump variable's movement is discontinuous and non-differentiable) end up being required to place the system on the stable path agents may lose faith in the model and the perfectness of their foresight. Neither is it good enough for the jump variable to move to a range in which it vacillates around a mean of the targeted value of the jump variable (though this type of behaviour would seem more in keeping with observed movements of variables in the real world) since such behaviour in a model similar to B & M's could only be explained as an endless series of mistake related jumps.

D. Agents Believe, or Act as if They Believe, that the Above Conditions will be Met

Finally, if saddlepoint stability is to be considered a feasible stability type, agents must behave as if they believe that they are able to correctly calculate the location of the equilibrium and stable path, agree on which of the infinite possible paths to equilibrium will be followed, and use the jump variable precisely to place the economy on that desired path. This may appear to be a trivial point, but it seems worthwhile to mention (without being overly philosophical) that lack of faith in one's abilities is often enough to prevent their effective use.

There are many possible reasons agents might experience a lack of confidence in their abilities to perform the tasks discussed in Sections III.A., III.B. and III.C. For instance, in response to the complaint that all economic agents are probably not capable of making the calculations outlined in Section III.A., it has been argued that a few professional economists make the calculations and sell them. The issue then arises as to how accurate the agents buying those calculations perceive them to be, not having made them and probably not really understanding them themselves.

Another source of indecisive behaviour might be found in a lack of confidence that all agents had agreed on the same path to equilibrium.

In any case, it would not take many agents acting indecisively (theoretically it would only take one such agent) to prevent the system from being jumped to the stable branch or equilibrium. The more times an incorrect jump was executed the more agents would presumably act indecisively, ultimately resulting in general breakdown of confidence in the model and the perfectness of foresight.

IV. Structural Stability or Robustness

In the last section we discussed the difficulties involved in using jump variables to position an economy or economic system. Throughout, it was emphasised that precision is required in that positioning if an economy in a system possessed of saddlepoint type stability is to be returned to equilibrium after a shock. Precision is required in such systems because only by jumping exactly onto the unique stable branch of the system will equilibrium be achieved; even an infinitely small near miss will result in explosive behavior or the need for another jump.

Related to this need for precision, but coming from a different direction, is the idea of structural stability or robustness. This is not the same structural stability--which I referred to as structural constancy to avoid confusion--discussed and tested for in the three previous empirical chapters. The structural stability discussed in this section--hereafter we shall adopt George and Oxley's (85) terminology and refer to this phenomenon as robustness--refers to the way any combination of changes in the coefficients and initial conditions of a model affect the path taken by the economy. If arbitrarily small perturbations in the coefficients and/or initial conditions do not cause the economy to follow a path that is qualitatively different from the path being followed pre-perturbation, then the type of path followed pre-perturbation is said to be a robust characteristic of the model.

For instance, if an economic system is assumed to display universal stability as in Diagram S4, then a perturbation to the system that alters coefficients in a way that makes the DL=O line shift to the left will force the economy to follow a different path than it would have followed, but the system still returns to equilibrium and

Diagram S4

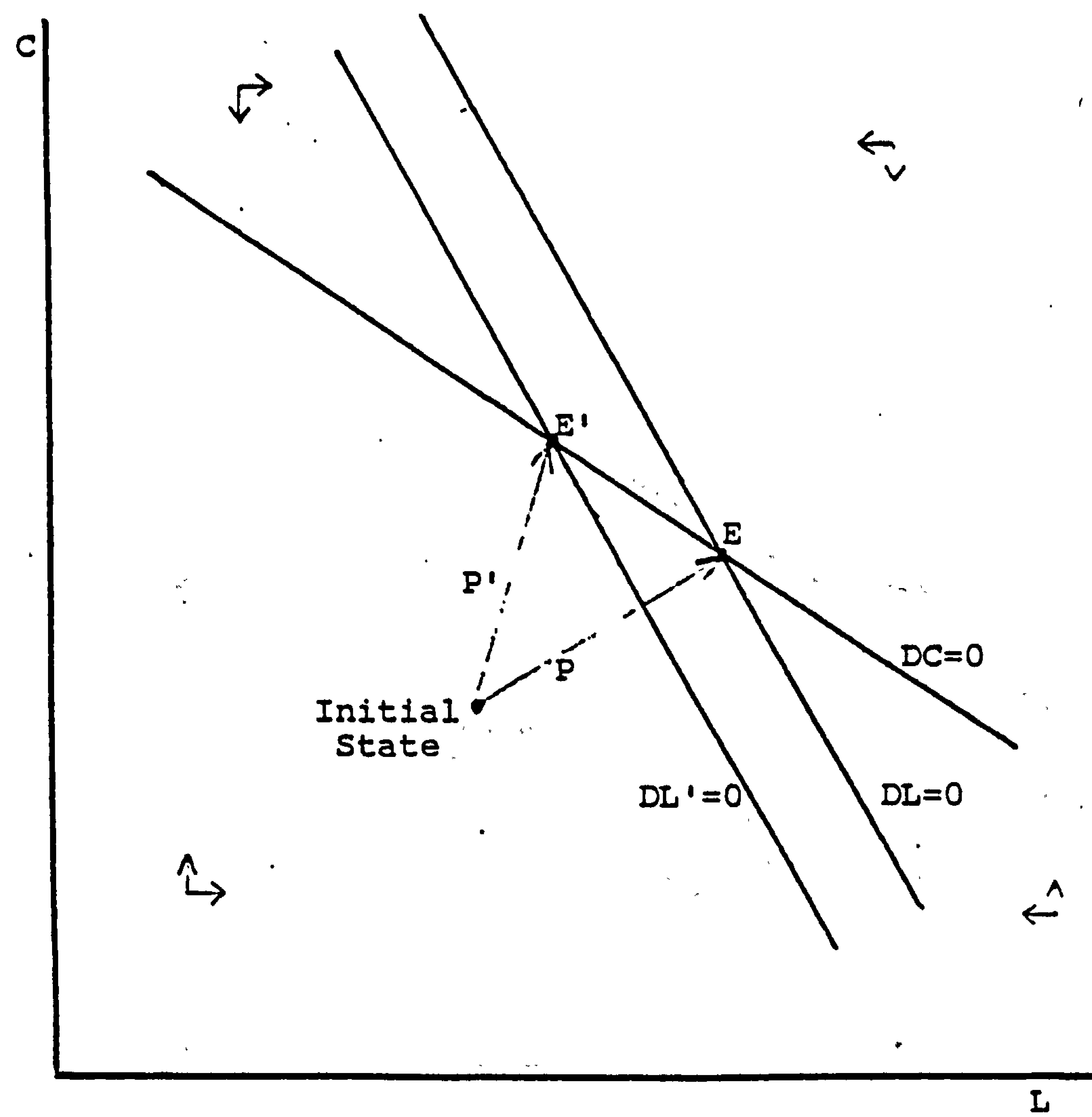


Diagram S5

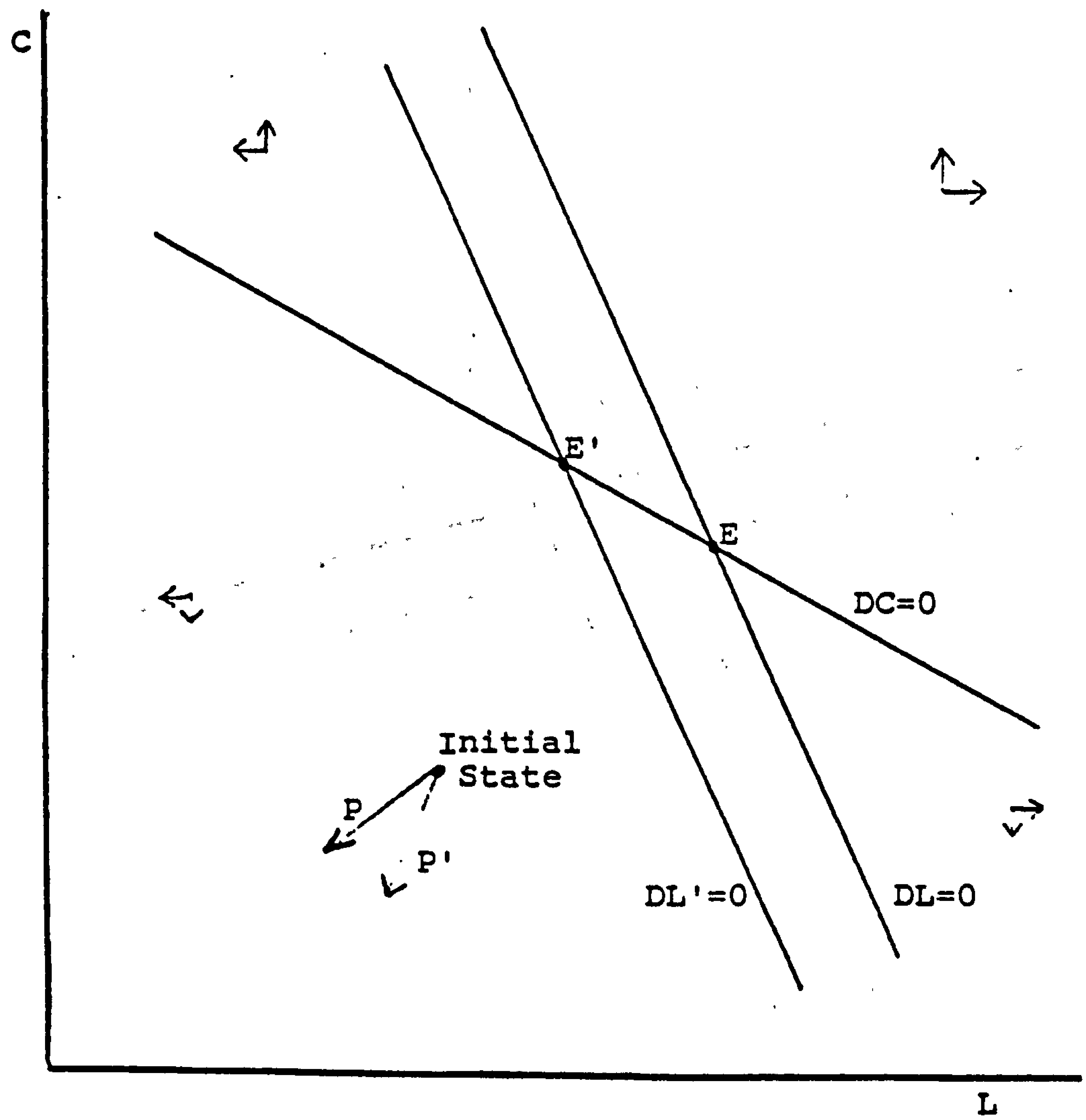
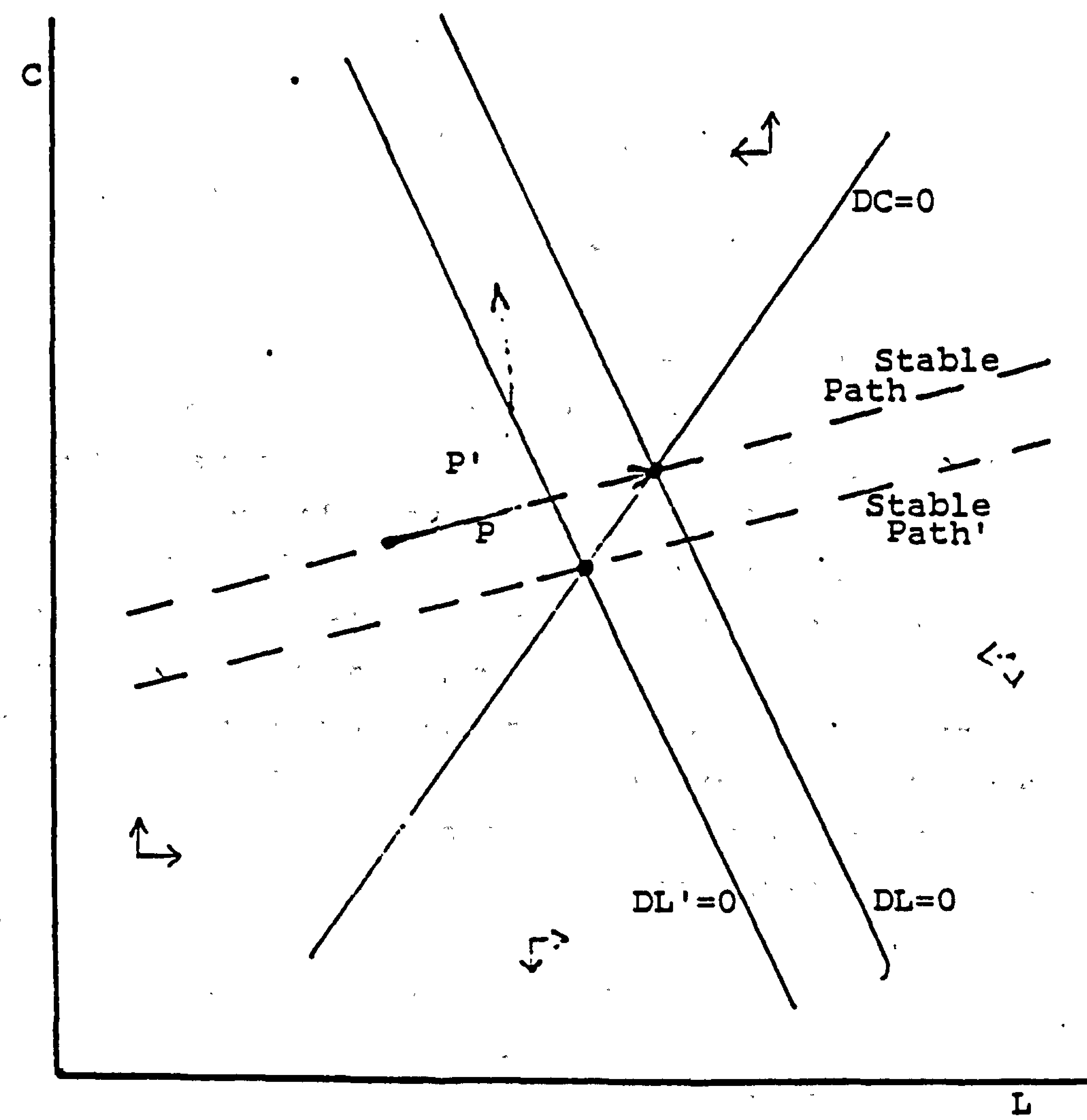


Diagram S6



therefore is still stable. Likewise, as in Diagram S5, if a system displays instability, then a perturbation to the system that shifts the DL=O line to the left does not affect the stability of the system. In both of these cases the stability type is said to be a robust characteristic of the system because, with respect to stability, the response of the economy to a shock is preserved despite minor alteration of the coefficients of the model.

As is shown in Diagram S6, however, stability is not a robust characteristic of saddlepoint models. Any alteration of the coefficients of the model that shifts the DL=O line to the left will result in a downward shift in the stable branch. If the economy was travelling along the stable branch (exhibiting stable behavior) prior to perturbation, it will, postperturbation, find itself on one of the infinite explosive paths (exhibiting unstable behavior). Instability is, in general, a robust characteristic of saddlepoint type models, since (except in the rare case that perturbation results in a shift that happens to place the economy on the stable branch) perturbation of an economy that is following one of the explosive paths will simply move the economy to another of infinite explosive paths, meaning that instability is preserved.

Thom (76, p. 14) has argued that:

> "The concept of structural stability seems to me to be the key idea in the interpretation of phenomena of all branches of science (except perhaps quantum mechanics).....forms that are subjectively identifiable and are represented in our language by a substantive are necessarily structurally stable forms; any given object is always under the disturbing influence of its environment, and these influences, however slight will have some effect on its form..... Therefore there is an open set.....consisting of the structurally stable form; and the unstable forms, which can be changed by an arbitrary small perturbation belong to its complement,

> which is closed. These unstable forms do not merit the name of forms and are strictly nonforms."

Applying his analysis to the case of stability in the context of a saddlepoint model (which we have shown above to be a non-robust characteristic of such a model), Thom is saying that, because the system represented by the model will be perpetually perturbed if it exists in the real world--that is, the DL=0 line (and the DC=0 line) will be continuously shifted around by stochastic events in the world--, adherence of the system to the stable path over any period of time will be so shortlived that it will be unobservable and the system will be seen to be unstable. This point overlooks the possibility that every shock to the system is met with a perfectly compensating jump variable correction--though the debilitating effect on this jump variable mechanism of frequent shocks was discussed in subsection III.A.

V. Conclusion

The present chapter has represented a theoretical break from the three preceding chapters which concentrated on empirics. The change in methodology is justified on the grounds that a "true" model should be both theoretically reasonable and consistent with empirics, but that the former may be the best basis on which to generate models for testing. Having found the three models examined in those previous chapters to show signs of dynamic misspecification, the present chapter has studied expectation formation as one possible area in which these models and others could be made more dynamically sophisticated.

The topic of expectation formation equations was first discussed in the review of the literature chapter, but rational expectations--arguably the most sophisticated of the mechanisms discussed there--has been considered more closely here. A model developed by Buiter and Miller was presented as representative of rational expectations type models, and some of its qualities and characteristics were discussed. The assumption that agents are possessed of perfect information--a common assumption in such models--couples with the assumption that expectations are formed rationally to mean that agents are possessed of perfect foresight--though the time horizon of that perfect foresight is not specified. The stability type of this model, namely, saddlepoint, was discussed, along with the jump variable mechanism, which is required if a model displaying saddlepoint stability is not to exhibit explosive behaviour.

Criticism of this saddlepoint/jump variable formulation makes up the remainder of the chapter. It was argued that in order to use the jump variable to move the economy to equilibrium agents must be able to A) correctly and accurately calculate the location of the system's equilibrium point and stable branch, B) all agree that the stable branch should be followed and equilibrium achieved, C) use the jump variable accurately, and D) act as if they believe that the first three conditions will be met. This all seems a tall order to fill--especially considering that it is not clear over what time horizon agents' foresight is perfect. Finally, the idea of structural stability or robustness was used to argue that stability is not, in general, an observable characteristic of saddlepoint models and as such, saddlepoint models must be considered primarily as being unstable.

Conclusion

Conclusion

The results of this thesis have been presented in detail on a chapter by chapter basis. I will therefore summarize only briefly here, focussing instead on the overall conclusions to be drawn from this work.

Although the three empirical models studied included increasing degrees of dynamic sophistication, each was found to be insufficiently sophisticated--evidence was produced to show that none of them is the 'true' model. The conclusion that these models are dynamically misspecified means that the statistics estimated in the regressions may be biased, and as such, are of questionable value for drawing further conclusions. Never-the-less, other empirical studies were done on these models, and the conclusions tentatively stated, with the hope that the statistics estimated are not sufficiently biased to make them completely useless.

Empirical work on all three of the models indicated the existence of structural breaks in the data over the period estimated (January, 1972 through February, 1980). Only the break around June, 1979--corresponding to the Thatcher Government's removal of restrictions on international capital flows--was identified by all three models.

Each of the three models also showed signs of sensitivity to the money supply and/or interest rate and/or price level measures used in estimation. Since any of the money supply, interest rate and price level measures was arguably appropriate for use in estimation, this finding further detracts from the conclusiveness of any empirical work on these models.

On the basis of log likelihood ratio and Davidson and MacKinnon's non-nested tests, there is some evidence that the stock/flow model explains exchange rate movements significantly better than the Dornbusch or monetary models, but there is no evidence that the Dornbusch models has significantly more explanatory power than the monetary model.

Since each of these models was rejected on the basis of dynamics (on the basis of evidence that each showed signs of dynamic misspecification), it seems logical that future attempts at modelling should focus on enhancing the dynamic character involved. Added dynamic complexity and realism might be obtained through the extension of any one or a combination of several of the components of the models studied here. Recently, the most widely studied component of exchange rate and other macroeconomic modelling has been the expectation formation mechanism. Although other extensions of this component exist, most of the attention in this area has been focussed on the rational expectations formation mechanism. Yet, as was discussed in this paper, the most commonly used formulation (the saddlepoint/jump variable formulation) of the rational expectations approach has some exceptionally unattractive theoretical qualities. Stability is not a robust or structurally stable characteristic of systems possessed of saddlepoint stability, and the attainment of equilibrium requires that economic agents are capable of impossible degrees of information finding, calculation, and control of economic variables. Clearly, formulations that avoid these shortcomings must be found before application of this approach to empirical models is warranted or wise.

It must be noted, however, that these criticisms do not apply solely to rational expectations models. It was discussed in chapter 4 that the regressive expectations formation mechanism (used in both the Dornbusch and the stock/flow models in this paper) requires that economic agents calculate the long run steady state value of the exchange rate. To the extent that agents must be able to accurately calculate this value in order to place the economy on the assumed solution path, and to the extent that that path must be followed--for whatever reason--, this mechanism is subject to the above criticisms. Thus, all dynamic models must be scrutinized for forward looking parts and saddlepoint type (containing unique acceptable or assumed solution paths) aspects. Models must be developed that do not require economic agents to have perfect forsight over all time and that are not as sensitive to parameterization and shocks as are saddlepoint type models.

These shortcomings in the usual formulation of the rational expectations approach do not, however, mean that the approach can not be usefully employed. The idea that economic agents do not make systematic errors, which is the main contribution of the rational expectations approach, should be incorporated in ways that produce models with universal stability. Acknowledging the possibility of errors on individual forecasts (even though their average expectational error is zero), agents might well make only partial adjustment of their capital stocks in response to a shock, the degree of adjustment depending, for instance, on the variance of past errors. This kind of partial adjustment would not occur in a saddlepoint/jump variable type model (in which agents would be required to possess infinite horizon perfect foresight in order to use the jump variables to restore equilibrium), but would cause no problems in a universally stable model. It seems, therefore, that the rational expectations approach might be fruitfully applied to exchange rate modelling, but the pitfalls discussed in chapter 6 must be avoided.

Bearing in mind the constraints that the above comments impose, we turn to another result of the work in this paper, which may give some insight into a way further empirical work could be used to better understand the dynamics involved in exchange rate movements. It was observed in chapters 3 and 5 (to the extent the stock/flow model developed in chapter 5 is subject to the theoretical arguments of chapter 6, the general principle discussed below can not be applied to that model) that a model may be shown to be dynamically misspecified when regressed using monthly data, but that the same model may not show significant signs of dynamic misspecification when regressed using quarterly data. This seems to point to the conclusion that various models and their dynamic formulations are operative over different time frames (a day, a month, a quarter, a year, for instance). This conclusion has intuitive appeal since various theoretical models are stated or implied to be relevant over different time frames, as was mentioned in the review of the literature. Yet most published empirical studies seem to make the choice between monthly, quarterly, or other data solely on the basis of availability and the number of degrees of freedom afforded, paying no attention to which time frame might be most consistent a priori with the dynamics of the model. By estimating models with data of various horizons (monthly, quarterly, etc.) it might be possible to determine or confirm the time frames over which various models are operative and relevant, to gain some concrete measure of the amount of time between t and t+1 in each model, and to better understand the dynamics of exchange rate movements.

A final conclusion relates to the sensitivity studies done in each of the empirical chapters. As was mentioned above, most of the estimations studied were shown to be significantly affected by the use of different, but still arguably appropriate, sets of data for the variables considered. In one sense, this was a negative result, reducing the confidence with which any conclusions can be drawn from the empirical work. But from a methodological point of view, this is clearly a positive result, providing strong evidence of the importance of such sensitivity studies to thorough econometric work. Leamer (see Leamer (85) for discussion and references) and others have recently emphasized the role of sensitivity studies in helping to 'take the con out of econometrics', but this remains one of the many ways in which most empirical studies are lacking in rigor. The ad hoc use of autoregressive techniques discussed in chapters 2 and 3 is another shortcoming common in published econometric work. Thus, not only is there a shortage of econometric work on exchange rate modelling (Leontief (82) has argued that this shortage pervades all of economics), but the work done is often so poor as to be of limited use or even misleading. More thoughtful, cautious, and rigorous econometric work is needed in future if empirics are to properly contribute to the evolution of theory and the development of exchange rate modelling.

There are, of course, an infinite number of directions that extensions from the present research might take--above are mentioned those that seem to logically flow out of the conclusions of the thesis. It is this vast potential for important and stimulating research that will continue to make the study of exchange rate and balance of payments modelling exciting for many years to come.

APPENDIX

Quarterly Data

A few things stand out in the quarterly data as presented here. A single trend line is clearly discernable in the domestic and foreign money supply and price level data, whereas any sort of trend line is much more difficult to see in the domestic and foreign interest rate data and the net capital flows data. As indicated by standard deviations, UK prices changed considerably more than did their foreign counterparts, while, in percentage terms (comparing ratios of std dev/ mean), UK money supply changed slightly less than its foreign counterparts. Both plotting and the descriptive statistics reported indicate that, apart from scaling, there is very little difference between the 5 and 17 country data for foreign money supply and also very little difference between the 5 and 17 country data for foreign income.

Key to Symbols for Quarterly Data

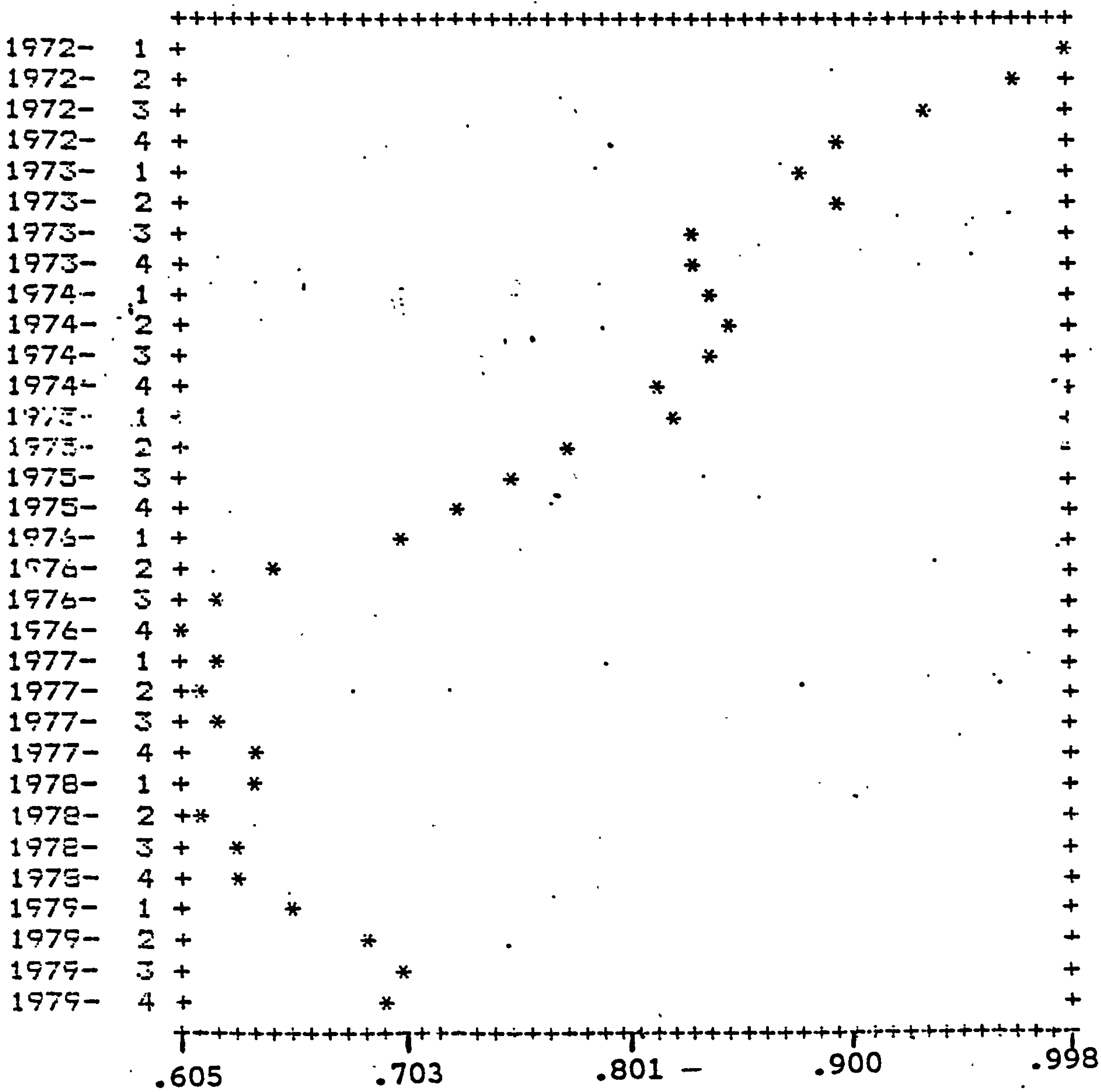
Symbol	Description
EER	17 Country MERM Weighted Average Effective Exchange Rate for the UK
M	Sterling M3 Money Supply for the UK
MF5	MERM Weighted Average of M3 Money Supplies of the UK's 5 Major Trading Partners
MF17	MERM Weighted Average of M3 Money Supplies of the UK's 17 Major Trading Partners
Y	Income for the UK
YF5	MERM Weighted Average of Incomes of the UK's 5 Major Trading Partners
YF17	MERM Weighted Average of Incomes of the UK's 17 Major Trading Partners
i	3-month Sterling Interbank Interest Rate
i_f	3-month London Eurodollar Interest Rate
P	Consumer Price Index for the UK
P_f	MERM Weighted Average of CPI's for the 5 Major Trading Partners of the UK
ΔB	Net Foreign Capital Flows of the UK

DESCRIPTIVE STATISTICS

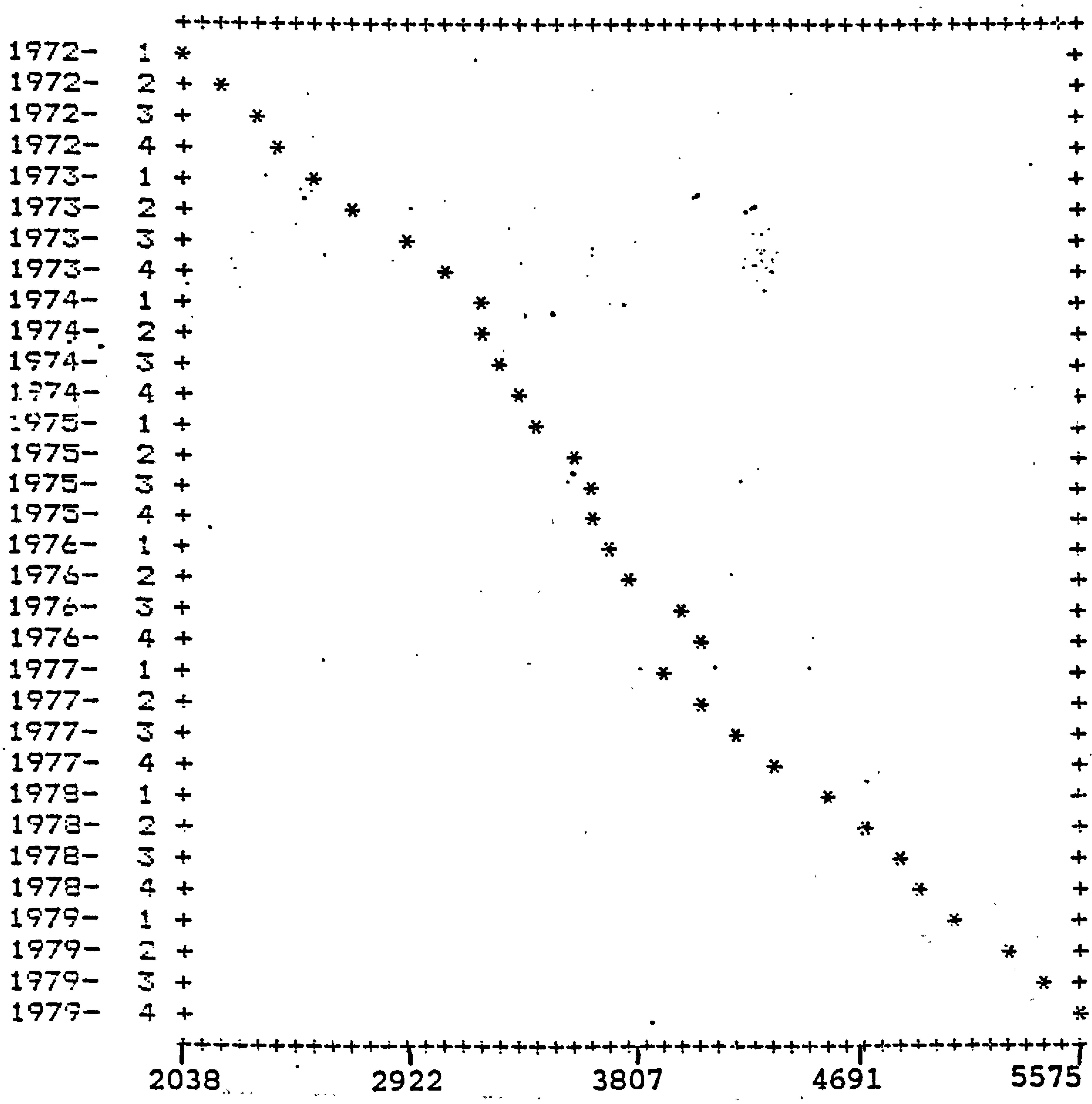
QUARTERLY DATA

VARIABLE	MEAN	MAX VALUE	MIN VALUE	STD DEV
EER	.7481	.998	.605	.1195
M	3746.	5575.	2038.	971.
MF5	270.9	400.2	167.9	75.4
MF17	293.8	442.1	179.6	83.5
Y	105.8	115.2	96.3	4.6
YF5	70.62	80.70	62.24	5.26
YF17	109.2	124.6	95.7	7.7
I	10.73	17.06	4.87	3.06
IF	8.38	14.50	5.06	2.71
P	109.6	176.2	68.8	36.0
PF	103.4	140.3	73.4	20.1
ΔB	1272.9	4249.	-873.	1415.0

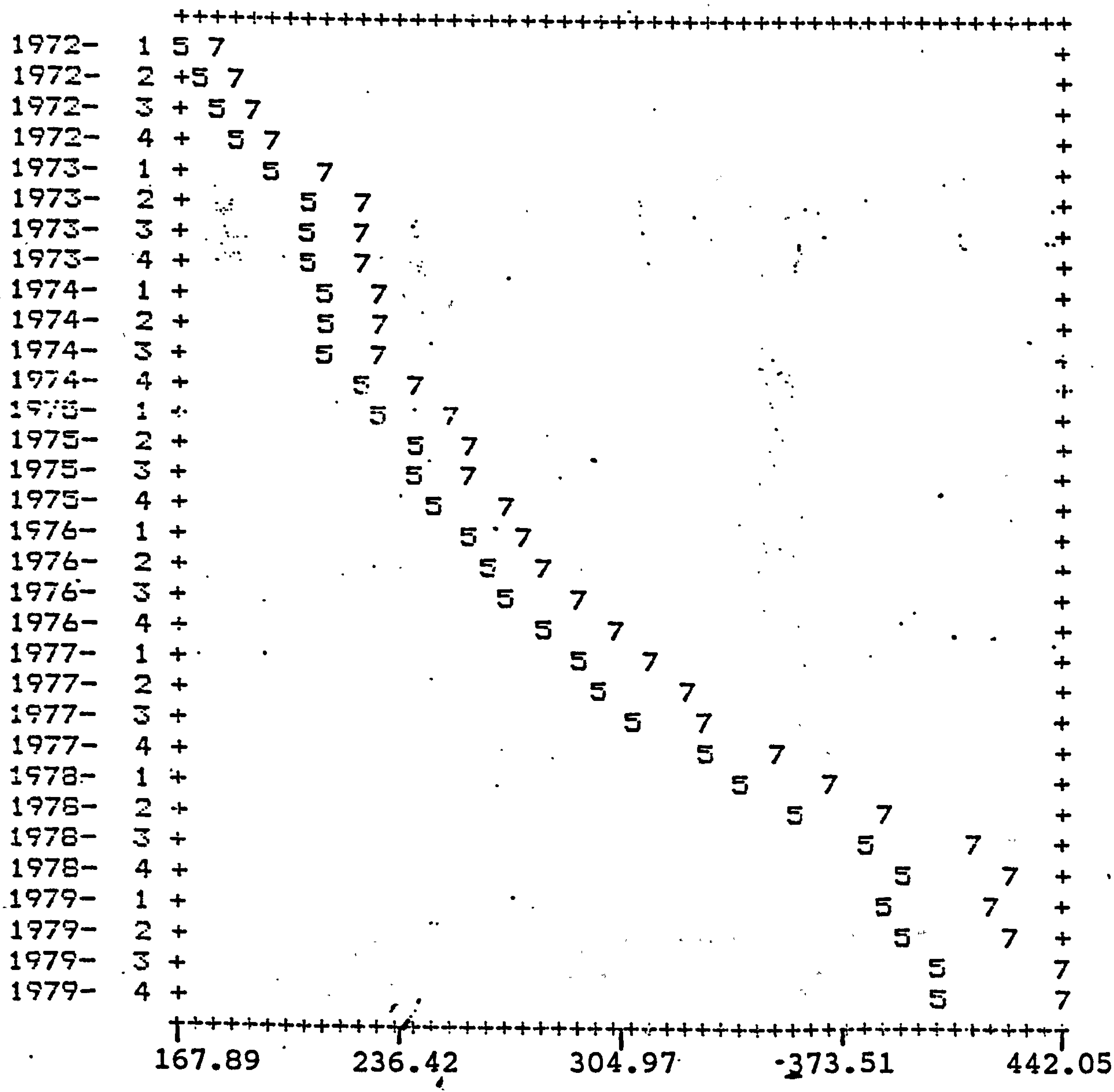
Plot of United Kingdom Effective Exchange Rate (EER) Quarterly Data Over Time



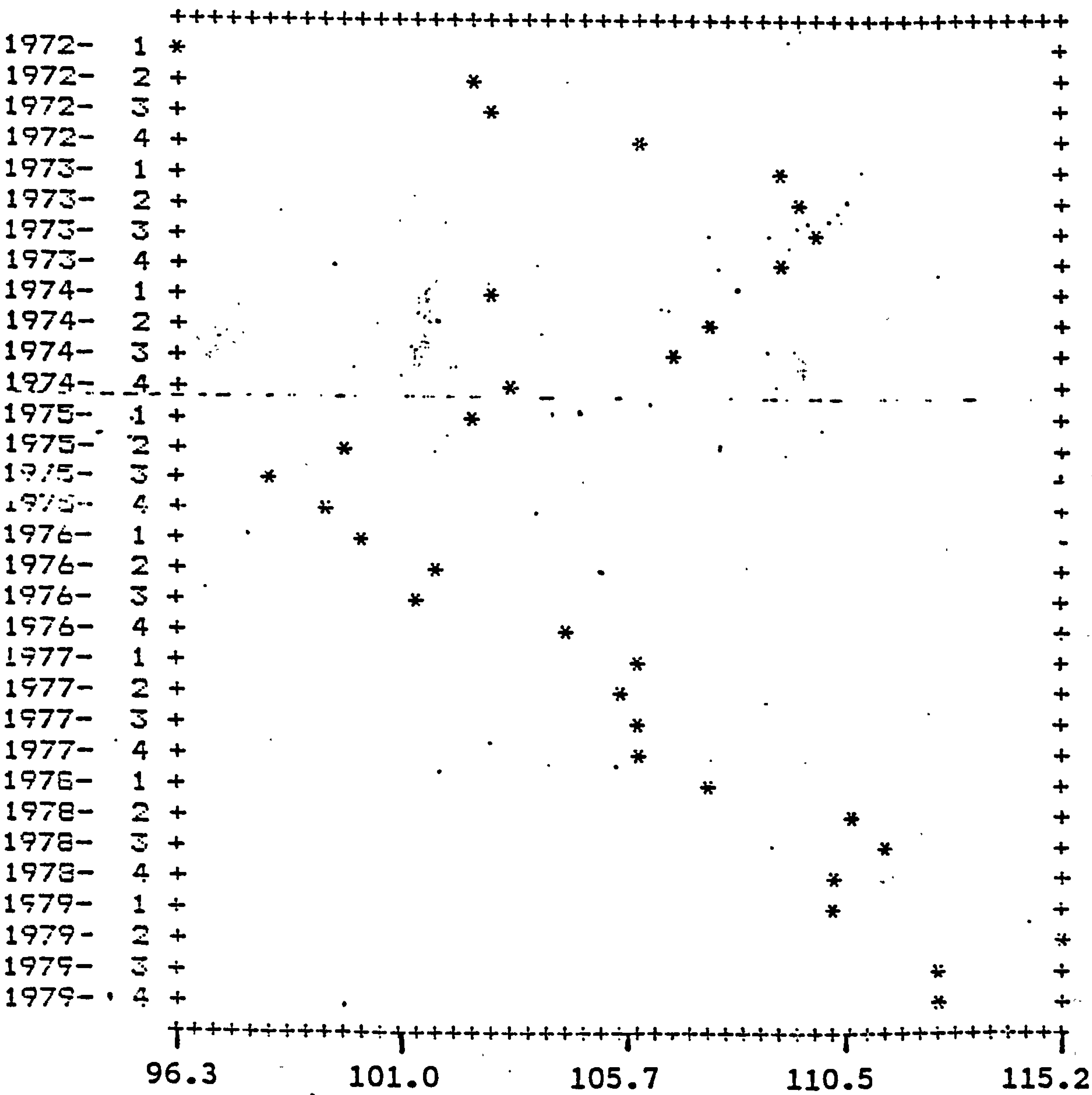
Plot of United Kingdom Money Supply (M)
Quarterly Data Over Time



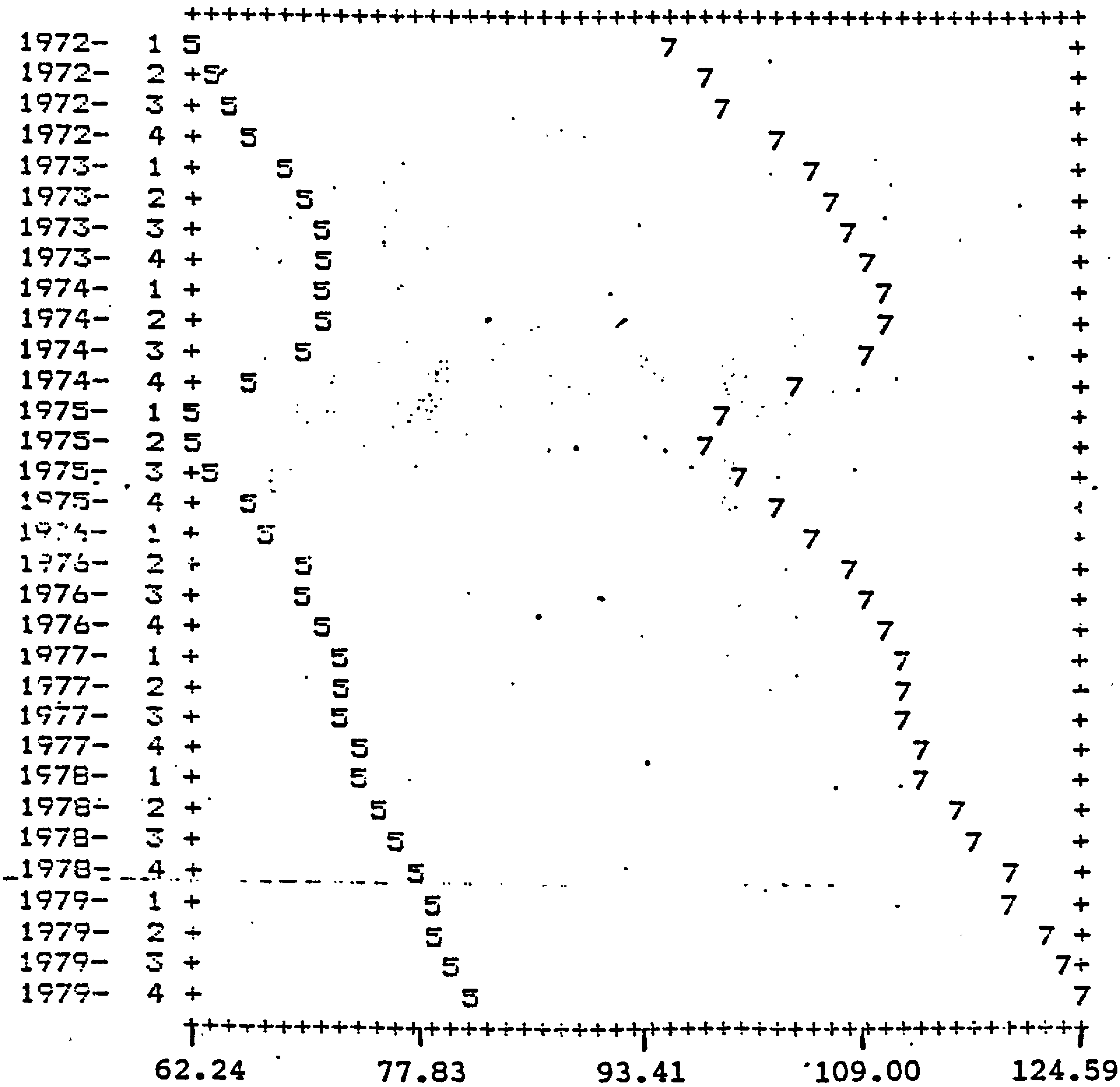
Plot of Five (Plotted as 5) and Seventeen (Plotted as 7) Country Foreign Money Supply (M_f) Quarterly Data Over Time



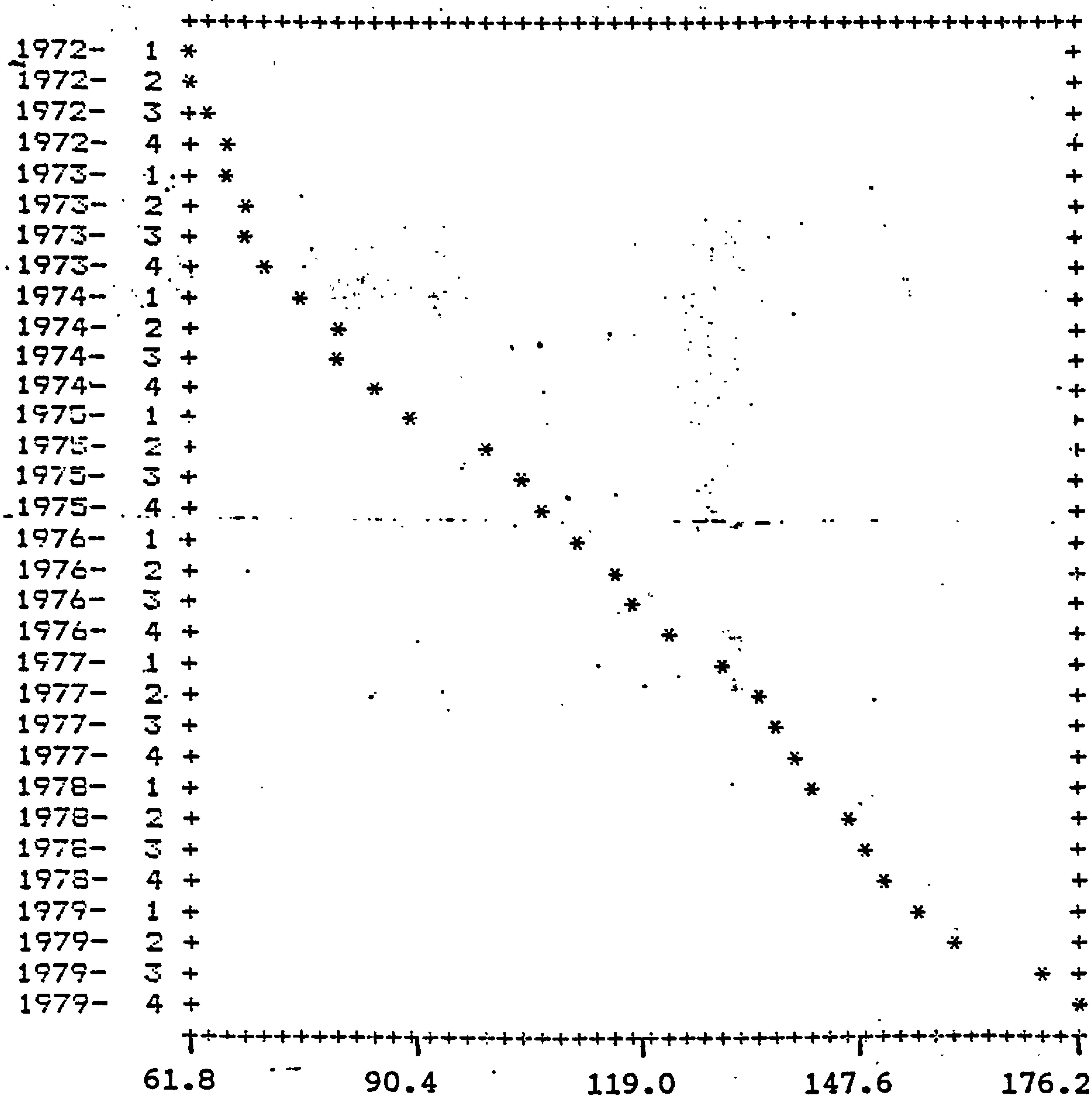
Plot of United Kingdom Income (Y)
Quarterly Data Over Time



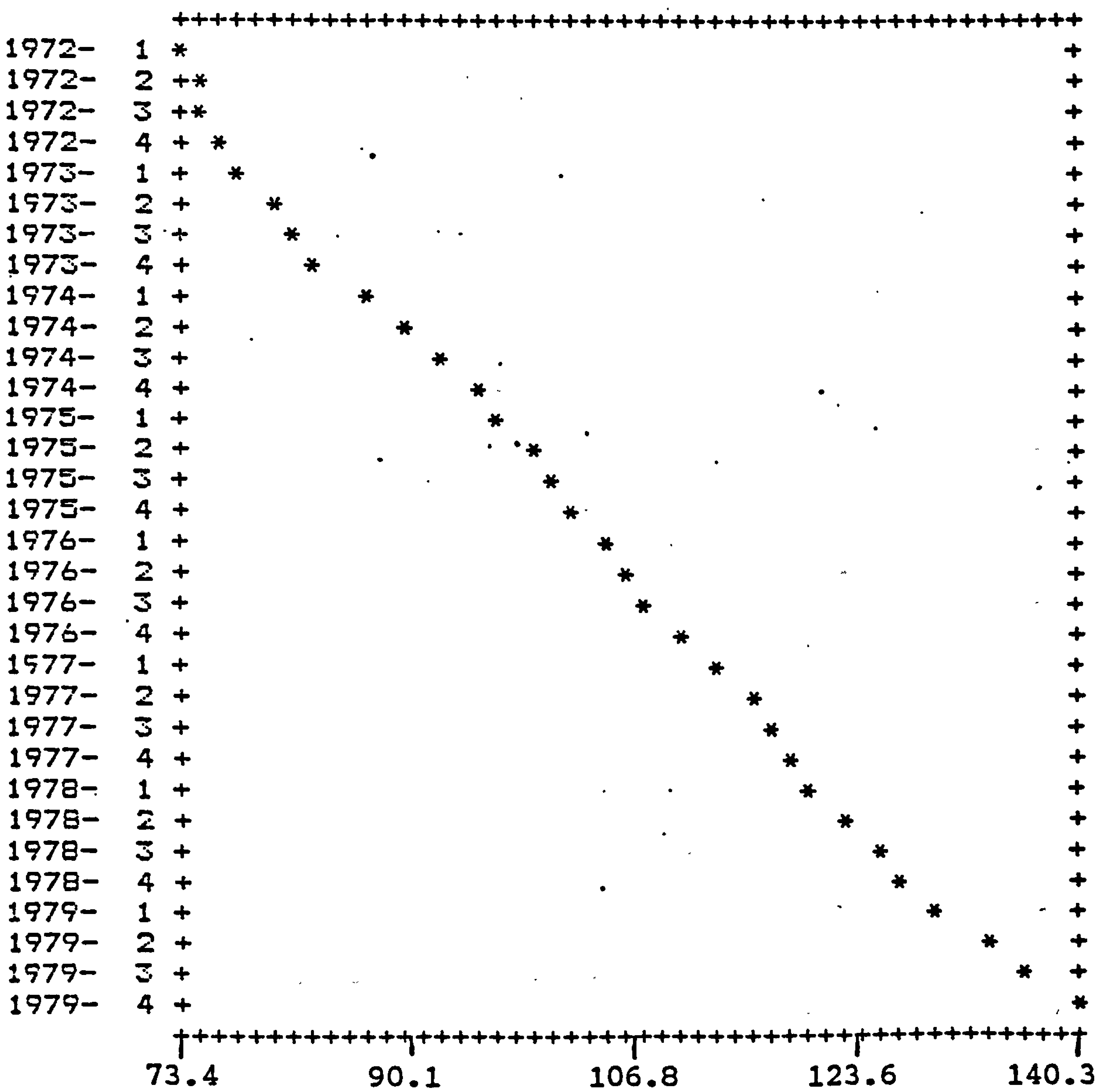
Plot of Five (Plotted as 5) and Seventeen (Plotted as 7) Country Foreign Income (Y_f) Quarterly Data Over Time



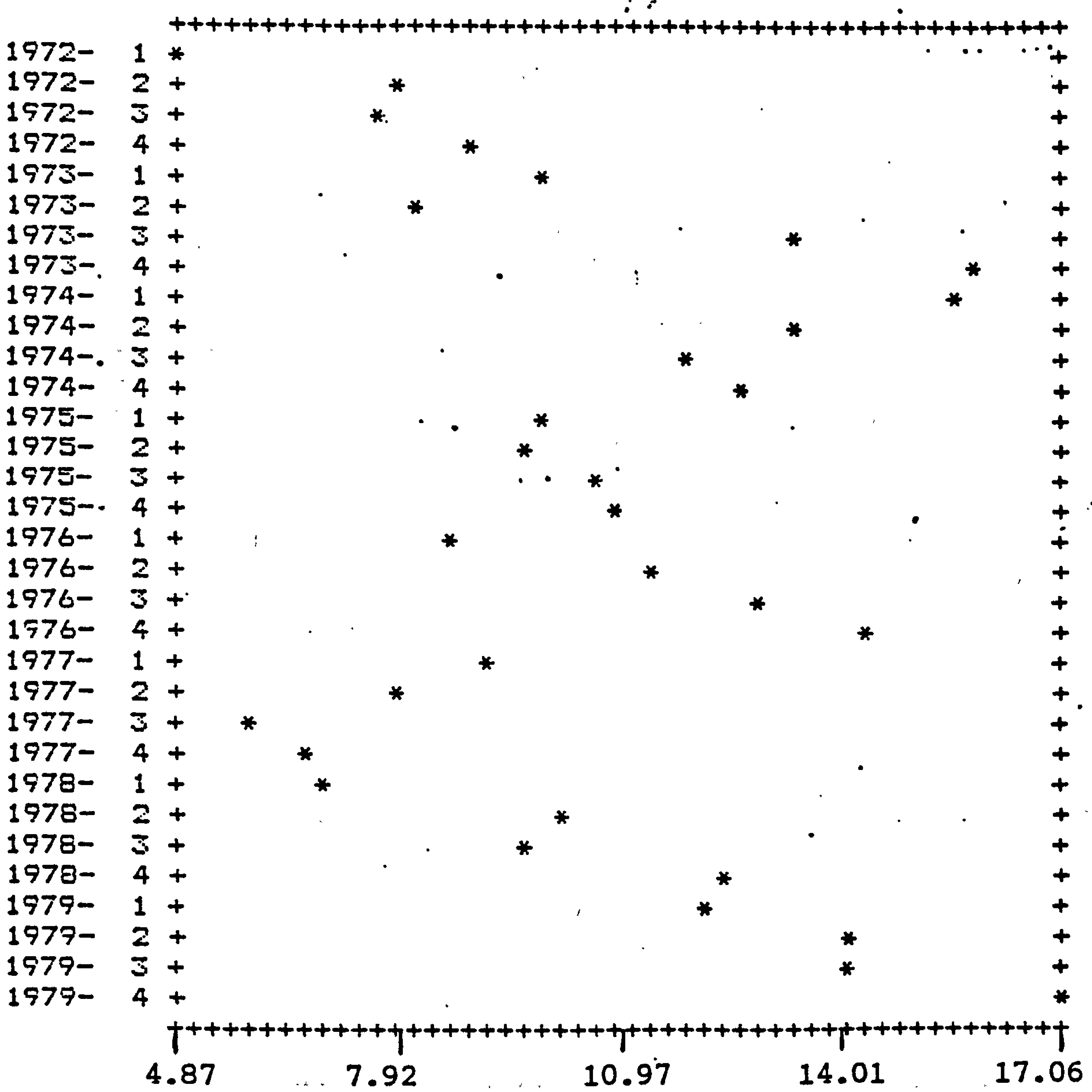
Plot of United Kingdom Price (P) Quarterly Data Over Time



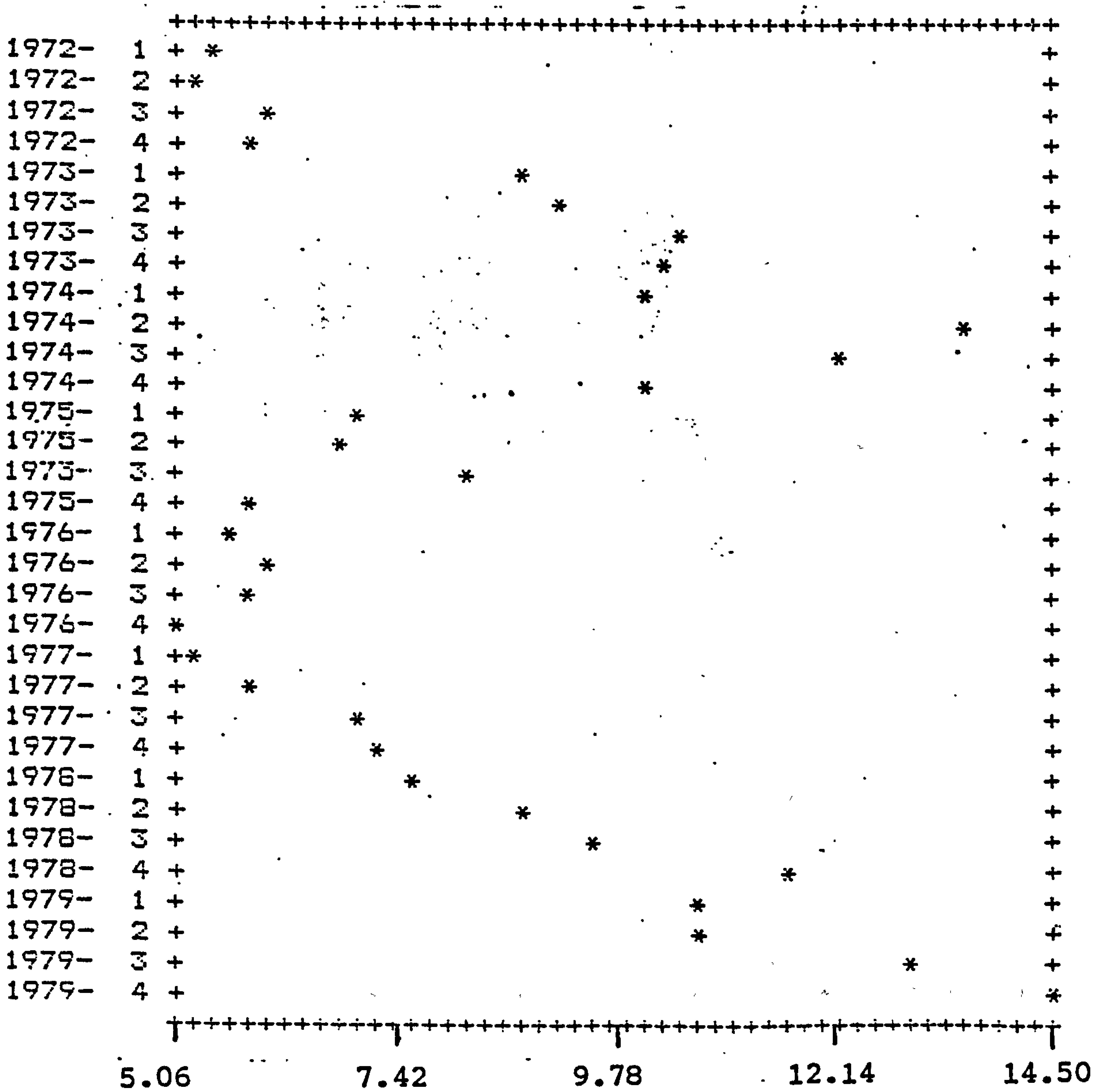
- Plot of Foreign Price (P_f) Quarterly Data Over Time



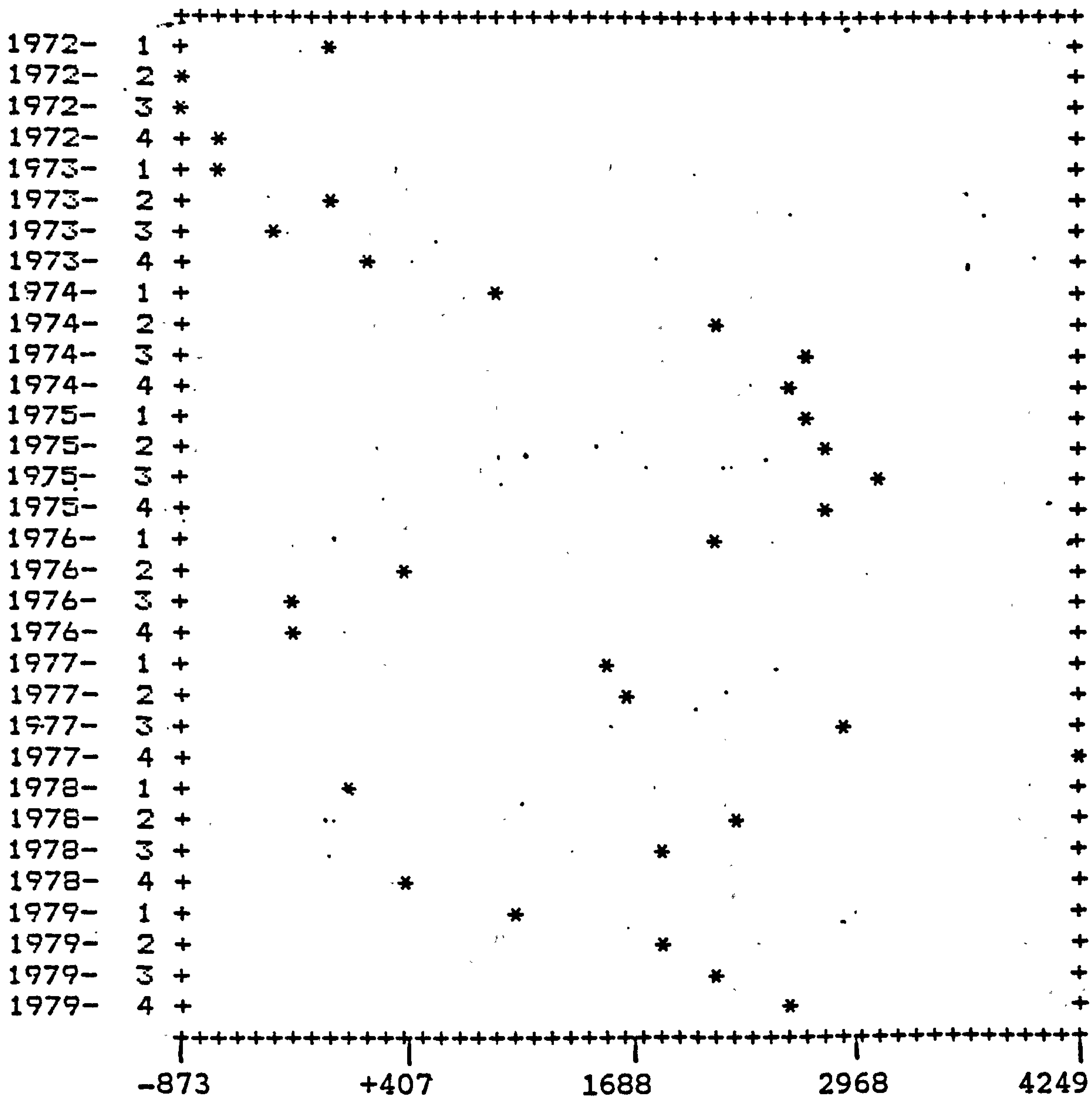
Plot of United Kingdom Interest Rate (i)
Quarterly Data Over Time



Plot of Foreign Interest Rate (i_f)
Quarterly Data Over Time



Plot of United Kingdom Net Capital Flows (ΔB) Quarterly Data Over Time



Quarterly Data

Entry		EER	P	PF
1972-	1	.998000	61.8000	73.4000
1972-	2	.977000	62.9000	74.3000
1972-	3	.930000	64.0000	75.2000
1972-	4	.895000	65.5000	76.2000
1973-	1	.877000	66.7000	77.6000
1973-	2	.892000	68.8000	79.6000
1973-	3	.826000	69.8000	81.2000
1973-	4	.826000	72.3000	83.4000
1974-	1	.839000	75.2000	86.8000
1974-	2	.848000	79.7000	89.6000
1974-	3	.836000	81.5000	92.3000
1974-	4	.816000	85.4000	95.1000
1975-	1	.819000	90.5000	97.2000
1975-	2	.774000	99.1000	99.1000
1975-	3	.746000	103.400	100.800
1975-	4	.726000	107.000	102.700
1976-	1	.705000	110.800	104.500
1976-	2	.643000	114.900	106.600
1976-	3	.625000	117.500	108.100
1976-	4	.605000	123.000	110.200
1977-	1	.619000	129.200	112.400
1977-	2	.615000	135.000	115.100
1977-	3	.624000	137.100	116.600
1977-	4	.638000	139.100	118.100
1978-	1	.641000	141.400	119.800
1978-	2	.613000	145.300	122.700
1978-	3	.627000	147.800	124.800
1978-	4	.632000	150.300	126.800
1979-	1	.650000	155.000	129.400
1979-	2	.683000	160.700	133.100
1979-	3	.698000	171.400	136.700
1979-	4	.697000	176.200	140.300

Quarterly Data

Entry		M	MF5	MF17
1972-	1	2038.00	167.890	179.550
1972-	2	2215.00	172.000	184.130
1972-	3	2296.00	177.420	189.970
1972-	4	2424.00	183.750	196.950
1973-	1	2579.00	196.590	211.000
1973-	2	2703.00	206.310	221.770
1973-	3	2880.00	207.950	224.580
1973-	4	3077.00	207.210	223.590
1974-	1	3182.00	213.610	230.810
1974-	2	3188.00	214.150	231.640
1974-	3	3274.00	212.770	230.370
1974-	4	3355.00	222.530	241.600
1975-	1	3437.00	229.830	250.460
1975-	2	3521.00	238.230	259.500
1975-	3	3609.00	237.850	258.220
1975-	4	3621.00	245.220	266.920
1976-	1	3715.00	254.820	275.290
1976-	2	3776.00	260.980	281.880
1976-	3	3983.00	270.750	292.550
1976-	4	4037.00	279.420	302.160
1977-	1	3940.00	291.890	315.410
1977-	2	4075.00	299.280	323.390
1977-	3	4233.00	308.180	332.830
1977-	4	4364.00	327.810	354.830
1978-	1	4548.00	342.220	371.460
1978-	2	4718.00	358.480	388.440
1978-	3	4831.00	379.670	412.640
1978-	4	4960.00	389.120	423.970
1979-	1	5039.00	383.420	419.110
1979-	2	5265.00	389.190	426.140
1979-	3	5418.00	400.120	439.960
1979-	4	5575.00	400.190	442.050

Quarterly Data

Entry		Y	YF5	YF17
1972-	1	96.3000	62.2400	95.7200
1972-	2	102.500	63.5500	98.0200
1972-	3	103.000	64.6900	99.1200
1972-	4	105.900	66.6500	102.570
1973-	1	109.200	68.8600	104.910
1973-	2	109.500	69.9300	107.210
1973-	3	109.900	70.6800	108.580
1973-	4	108.900	71.2000	109.890
1974-	1	102.700	70.9900	110.220
1974-	2	107.600	70.7900	110.620
1974-	3	106.700	69.9600	108.990
1974-	4	103.400	66.4900	104.160
1975-	1	102.500	62.3000	98.5100
1975-	2	99.6000	62.4100	98.4000
1975-	3	98.4000	64.0500	99.9400
1975-	4	99.5000	65.6700	102.630
1976-	1	100.300	67.7500	105.220
1976-	2	101.800	69.5600	108.510
1976-	3	101.500	70.3000	109.490
1976-	4	104.500	70.9400	110.580
1977-	1	106.100	71.9000	111.450
1977-	2	105.500	72.3800	111.840
1977-	3	105.800	72.5400	111.700
1977-	4	106.100	73.1100	112.530
1978-	1	107.500	73.7000	113.410
1978-	2	110.600	74.9200	115.450
1978-	3	111.200	76.2600	116.480
1978-	4	110.100	77.6800	119.370
1979-	1	110.200	78.1700	119.670
1979-	2	115.200	79.4000	122.010
1979-	3	112.500	80.1000	123.130
1979-	4	112.500	80.7000	124.590

Quarterly Data

Entry		i	i_f	AB
1972-	1	4.87000	5.53000	-10.0000
1972-	2	7.75000	5.31000	-848.000
1972-	3	7.56000	5.94000	-873.000
1972-	4	8.94000	5.91000	-711.000
1973-	1	9.94000	8.69000	-635.000
1973-	2	8.13000	9.06000	-65.0000
1973-	3	13.2500	10.4700	-332.000
1973-	4	15.8100	10.1900	195.000
1974-	1	15.5000	10.0000	913.000
1974-	2	13.4400	13.5000	2118.00
1974-	3	11.7500	12.1900	2648.00
1974-	4	12.5600	10.0600	2571.00
1975-	1	9.94000	6.97000	2652.00
1975-	2	9.69000	6.75000	2766.00
1975-	3	10.6200	8.06000	3047.00
1975-	4	10.7200	5.87000	2774.00
1976-	1	8.50000	5.59000	2197.00
1976-	2	11.2200	6.00000	393.000
1976-	3	12.8100	5.81000	-259.000
1976-	4	14.3700	5.06000	-216.000
1977-	1	9.12000	5.25000	1491.00
1977-	2	7.75000	5.81000	1616.00
1977-	3	5.84000	6.91000	2853.00
1977-	4	6.66000	7.19000	4249.00
1978-	1	6.94000	7.50000	45.3800
1978-	2	10.1600	8.69000	2303.00
1978-	3	9.69000	9.53000	1858.00
1978-	4	12.4400	11.6900	427.000
1979-	1	12.1200	10.6600	977.000
1979-	2	14.0700	10.5900	1859.00
1979-	3	14.1600	12.8700	2131.00
1979-	4	17.0600	14.5000	2597.00

Monthly Data

Again there is a clearly defined single trend discernable in the plots of domestic and foreign money supply and price level data. The initial trend in the plot of UK effective exchange rate data appears to be broken around mid 1976--or about the time capital controls were being put on in the UK. Plots and std dev/ mean ratios seem to indicate that scaling may not be the only difference between the three domestic money supply measures considered, between the three domestic price level measures considered, and between the three domestic interest rate measures considered. In the later stages of the sample period M3 appears to be growing at a faster rate than sterling M3 which appears to be growing at a faster rate than M1. The three domestic price level measures tend to move in the same general direction, but their trend lines cross numerous times. Likewise, the three domestic interest rate measures are nearly identical at some points and widely divergent at others. The data for foreign money supply, income, and price levels seem to be more smooth than their domestic counterparts, but this effect is probably a result of the fact that the foreign data are averages of five countries data. Again UK prices appear to have changed more than their foreign counterparts in percentage terms.

Key to Symbols
for Monthly Data

Symbol	Description
EER	17 Country MERM Weighted Average Effective Exchange Rate for the UK
StgM3	Sterling M3 Money Supply for the UK
M3	M3 Money Supply for the UK
M1	M1 Money Supply for the UK
M_f	MERM Weighted Average of M3 Money Supplies of the UK's 5 Major Trading Partners
Y	Income for the UK
Y_f	MERM Weighted Average of Incomes of the UK's 5 Major Trading Partners
CPI	Consumer Price Index for the UK
XP	Export Prices for the UK
ULC	Unit Labor Costs for the UK
P_f	MERM Weighted Average of CPI's of the UK's 5 Major Trading Partners
IB	3-month Sterling Interbank Interest Rate for the UK
TB	3-month Sterling Treasury Bill Interest Rate for the UK
ES	3-month Paris Eurosterling Interest Rate
i_f	3-month London Eurodollar Interest Rate

DESCRIPTIVE STATISTICS

MONTHLY DATA

VARIABLE	MEAN	MAX VALUE	MIN VALUE	STD-DEV
EER	.7498	.998	.591	.1186
STGM3	3750.	5653.	1986.	995.
M3	4040.	6149.	2004.	1141.
M1	1766.	2819.	1038.	562.
MF	1.010	1.506	.604	.260
Y	106.3	119.0	95.0	5.6
YF	111.6	130.1	96.9	8.9
CPI	111.1	184.5	61.5	36.8
ULC	106.6	179.3	58.1	36.3
XP	105.9	194.7	62.0	34.0
PF	104.3	145.4	73.1	20.5
IB	10.83	18.19	4.53	3.11
TB	10.00	16.80	4.25	3.00
ES	12.15	21.19	5.06	3.57
IF	8.39	16.97	4.63	2.88

Plot of EER
Monthly Data
Over Time

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Plot of StgM3 (S),
M3 (3), and M1 (1)
Monthly Data
Over Time


Plot of M_f
Monthly Data
Over Time
.604
.829
1.055
1.281
1.506

Plot of Y
Monthly Data
Over Time

Plot of Y_f
Monthly Data
Over Time

Plot of CPI (C), XP (X), and ULC (U) Monthly Data Over Time

Plot of P_f
Monthly Data
Over Time

Plot of IB(I), TB (T), and ES (E) Monthly Data Over Time


Plot of i_f
Monthly Data
Over Time
4.63
7.72
10.80
13.89
16.97

Monthly Data

Entry	EER	Y	Y_f
1972- 1	.992000	95.0000	96.9900
1972- 2	.997000	97.0000	97.3300
1972- 3	.998000	96.0000	98.3700
1972- 4	.997000	98.0000	98.7900
1972- 5	.997000	100.000	99.5000
1972- 6	.977000	100.000	99.7700
1972- 7	.929000	99.0000	99.9600
1972- 8	.933000	100.000	101.440
1972- 9	.930000	102.000	101.770
1972- 10	.914000	103.000	103.540
1972- 11	.897000	104.000	104.650
1972- 12	.895000	105.000	106.380
1973- 1	.899000	107.000	106.400
1973- 2	.889000	106.000	107.750
1973- 3	.877000	107.000	108.170
1973- 4	.838000	107.000	108.290
1973- 5	.898000	107.000	110.090
1973- 6	.892000	109.000	110.050
1973- 7	.853000	108.000	109.880
1973- 8	.846000	108.000	111.490
1973- 9	.826000	108.000	110.840
1973- 10	.826000	109.000	111.620
1973- 11	.837000	108.000	112.010
1973- 12	.826000	107.000	111.470
1974- 1	.824000	100.000	111.840
1974- 2	.829000	100.000	111.390
1974- 3	.839000	104.000	110.790
1974- 4	.816000	107.000	111.120
1974- 5	.847000	108.000	111.920
1974- 6	.848000	108.000	111.130
1974- 7	.842000	108.000	111.600
1974- 8	.842000	108.000	110.500
1974- 9	.836000	106.000	109.570
1974- 10	.837000	105.000	107.750
1974- 11	.826000	105.000	104.540
1974- 12	.816000	103.000	101.230
1975- 1	.815000	104.000	98.9130
1975- 2	.816000	103.000	97.9660
1975- 3	.819000	101.000	96.9180
1975- 4	.810000	100.000	97.7160
1975- 5	.788000	99.0000	96.9760
1975- 6	.774000	99.0000	98.8440
1975- 7	.760000	99.0000	99.7480
1975- 8	.749000	97.0000	100.950
1975- 9	.746000	99.0000	101.730
1975- 10	.734000	100.000	102.590
1975- 11	.730000	100.000	102.920
1975- 12	.726000	99.0000	104.290

Monthly Data

Entry	EER	Y	Y_f
1976- 1	.728000	99.0000	105.450
1976- 2	.727000	100.000	107.670
1976- 3	.705000	101.000	108.200
1976- 4	.672000	102.000	108.910
1976- 5	.658000	104.000	109.690
1976- 6	.643000	102.000	110.300
1976- 7	.651000	102.000	110.890
1976- 8	.648000	102.000	111.270
1976- 9	.625000	103.000	112.120
1976- 10	.592000	105.000	111.370
1976- 11	.591000	105.000	112.910
1976- 12	.605000	106.000	113.500
1977- 1	.618000	108.000	113.920
1977- 2	.617000	108.000	113.560
1977- 3	.619000	108.000	115.050
1977- 4	.617000	107.000	113.940
1977- 5	.616000	109.000	114.300
1977- 6	.615000	106.000	114.810
1977- 7	.610000	107.000	114.330
1977- 8	.620000	108.000	114.900
1977- 9	.624000	108.000	115.390
1977- 10	.625000	107.000	114.600
1977- 11	.636000	107.000	115.530
1977- 12	.638000	108.000	115.570
1978- 1	.660000	109.000	116.140
1978- 2	.660000	109.000	115.970
1978- 3	.641000	108.000	117.140
1978- 4	.618000	112.000	118.610
1978- 5	.615000	111.000	118.370
1978- 6	.613000	111.000	118.850
1978- 7	.621000	112.000	119.860
1978- 8	.624000	113.000	120.160
1978- 9	.627000	112.000	121.210
1978- 10	.625000	110.000	122.220
1978- 11	.625000	111.000	122.930
1978- 12	.632000	113.000	123.630
1979- 1	.635000	117.000	123.260
1979- 2	.637000	116.000	124.110
1979- 3	.650000	117.000	124.890
1979- 4	.669000	116.000	123.950
1979- 5	.669000	118.000	124.970
1979- 6	.683000	119.000	125.000
1979- 7	.719000	118.000	127.080
1979- 8	.714000	114.000	125.940
1979- 9	.698000	112.000	126.390
1979- 10	.684000	113.000	129.760
1979- 11	.684000	116.000	127.700
1979- 12	.697000	114.000	127.490
1980- 1	.714000	114.000	128.230
1980- 2	.728000	113.000	130.090

Monthly Data

Entry	StgM3	M3	M1
1972- 1	1986.00	2004.00	1038.00
1972- 2	1989.00	2008.00	1041.00
1972- 3	2038.00	2080.00	1070.00
1972- 4	2085.00	2156.00	1098.00
1972- 5	2126.00	2192.00	1111.00
1972- 6	2215.00	2261.00	1132.00
1972- 7	2224.00	2309.00	1129.00
1972- 8	2247.00	2326.00	1134.00
1972- 9	2296.00	2373.00	1142.00
1972- 10	2314.00	2403.00	1160.00
1972- 11	2351.00	2426.00	1158.00
1972- 12	2424.00	2497.00	1180.00
1973- 1	2451.00	2558.00	1178.00
1973- 2	2545.00	2643.00	1184.00
1973- 3	2579.00	2684.00	1193.00
1973- 4	2601.00	2717.00	1229.00
1973- 5	2625.00	2733.00	1231.00
1973- 6	2703.00	2787.00	1239.00
1973- 7	2761.00	2889.00	1265.00
1973- 8	2809.00	2958.00	1266.00
1973- 9	2880.00	3028.00	1241.00
1973- 10	2947.00	3099.00	1219.00
1973- 11	2987.00	3137.00	1231.00
1973- 12	3077.00	3220.00	1233.00
1974- 1	3108.00	3250.00	1241.00
1974- 2	3175.00	3328.00	1232.00
1974- 3	3182.00	3345.00	1226.00
1974- 4	3174.00	3351.00	1257.00
1974- 5	3185.00	3385.00	1248.00
1974- 6	3188.00	3386.00	1238.00
1974- 7	3221.00	3473.00	1255.00
1974- 8	3288.00	3520.00	1269.00
1974- 9	3274.00	3518.00	1271.00
1974- 10	3292.00	3535.00	1290.00
1974- 11	3354.00	3576.00	1300.00
1974- 12	3355.00	3572.00	1322.00
1975- 1	3397.00	3606.00	1369.00
1975- 2	3441.00	3647.00	1386.00
1975- 3	3437.00	3676.00	1399.00
1975- 4	3465.00	3685.00	1412.00
1975- 5	3503.00	3735.00	1500.00
1975- 6	3521.00	3745.00	1519.00
1975- 7	3542.00	3772.00	1540.00
1975- 8	3621.00	3833.00	1592.00
1975- 9	3609.00	3854.00	1593.00
1975- 10	3624.00	3901.00	1597.00
1975- 11	3624.00	3878.00	1607.00
1975- 12	3621.00	3875.00	1627.00

Monthly Data

Entry		StdM3	M3	M1
1976-	1	3644.00	3914.00	1656.00
1976-	2	3714.00	3971.00	1696.00
1976-	3	3715.00	3992.00	1699.00
1976-	4	3731.00	4045.00	1748.00
1976-	5	3755.00	4068.00	1735.00
1976-	6	3776.00	4091.00	1723.00
1976-	7	3832.00	4149.00	1797.00
1976-	8	3918.00	4223.00	1803.00
1976-	9	3983.00	4319.00	1839.00
1976-	10	3980.00	4364.00	1819.00
1976-	11	4032.00	4412.00	1825.00
1976-	12	4037.00	4386.00	1843.00
1977-	1	3966.00	4340.00	1840.00
1977-	2	3943.00	4333.00	1853.00
1977-	3	3940.00	4340.00	1849.00
1977-	4	3998.00	4453.00	1891.00
1977-	5	4031.00	4492.00	1918.00
1977-	6	4075.00	4519.00	1959.00
1977-	7	4115.00	4547.00	1995.00
1977-	8	4168.00	4545.00	2032.00
1977-	9	4233.00	4620.00	2100.00
1977-	10	4266.00	4653.00	2141.00
1977-	11	4302.00	4656.00	2184.00
1977-	12	4364.00	4708.00	2207.00
1978-	1	4438.00	4800.00	2265.00
1978-	2	4523.00	4900.00	2304.00
1978-	3	4548.00	4959.00	2319.00
1978-	4	4635.00	5121.00	2327.00
1978-	5	4684.00	5208.00	2361.00
1978-	6	4718.00	5233.00	2354.00
1978-	7	4786.00	5283.00	2406.00
1978-	8	4788.00	5233.00	2436.00
1978-	9	4831.00	5267.00	2468.00
1978-	10	4873.00	5341.00	2491.00
1978-	11	4909.00	5387.00	2503.00
1978-	12	4960.00	5428.00	2543.00
1979-	1	5050.00	5532.00	2582.00
1979-	2	5078.00	5577.00	2595.00
1979-	3	5039.00	5508.00	2596.00
1979-	4	5141.00	5622.00	2673.00
1979-	5	5219.00	5720.00	2681.00
1979-	6	5265.00	5777.00	2651.00
1979-	7	5310.00	5783.00	2711.00
1979-	8	5384.00	5847.00	2723.00
1979-	9	5418.00	5877.00	2739.00
1979-	10	5516.00	6027.00	2819.00
1979-	11	5570.00	6110.00	2776.00
1979-	12	5575.00	6062.00	2766.00
1980-	1	5625.00	6115.00	2769.00
1980-	2	5653.00	6149.00	2728.00

Monthly Data

Entry	CPI	XP	ULC
1972- 1	61.5000	58.1000	64.9000
1972- 2	61.8000	58.6000	65.2000
1972- 3	62.0000	59.1000	65.9000
1972- 4	62.6000	59.0000	66.2000
1972- 5	62.9000	59.0000	66.2000
1972- 6	63.3000	59.2000	65.9000
1972- 7	63.5000	59.7000	62.8000
1972- 8	64.0000	60.1000	65.2000
1972- 9	64.4000	60.0000	64.3000
1972- 10	65.3000	60.0000	63.0000
1972- 11	65.5000	59.9000	62.0000
1972- 12	65.8000	59.1000	62.4000
1973- 1	66.2000	59.1000	63.5000
1973- 2	66.7000	59.5000	66.7000
1973- 3	67.1000	60.3000	69.5000
1973- 4	68.3000	61.0000	69.8000
1973- 5	68.8000	61.5000	71.4000
1973- 6	69.2000	61.9000	73.8000
1973- 7	69.5000	62.3000	74.1000
1973- 8	69.7000	63.2000	73.2000
1973- 9	70.3000	64.1000	72.4000
1973- 10	71.7000	65.1000	73.2000
1973- 11	72.3000	66.2000	74.1000
1973- 12	72.8000	67.1000	73.8000
1974- 1	74.2000	67.8000	72.2000
1974- 2	75.4000	68.8000	76.2000
1974- 3	76.1000	69.5000	81.1000
1974- 4	78.7000	71.7000	85.4000
1974- 5	79.8000	73.1000	87.3000
1974- 6	80.6000	75.8000	88.6000
1974- 7	81.4000	77.5000	89.0000
1974- 8	81.5000	79.9000	89.7000
1974- 9	81.6000	82.3000	89.8000
1974- 10	84.0000	85.0000	91.1000
1974- 11	85.5000	87.7000	93.1000
1974- 12	86.7000	89.1000	94.7000
1975- 1	88.9000	90.2000	102.100
1975- 2	90.4000	91.4000	102.500
1975- 3	92.2000	93.7000	104.000
1975- 4	95.8000	96.5000	103.300
1975- 5	99.8000	98.1000	102.200
1975- 6	101.700	100.200	101.600
1975- 7	102.700	102.100	98.7000
1975- 8	103.300	103.700	97.2000
1975- 9	104.200	104.700	97.4000
1975- 10	105.700	105.000	97.3000
1975- 11	107.000	106.700	98.0000
1975- 12	108.300	108.000	97.6000

Monthly Data

Entry	CPI	XP	ULC
1976- 1	109.700	109.300	99.6000
1976- 2	111.100	109.800	100.900
1976- 3	111.700	110.400	97.7000
1976- 4	113.900	110.500	95.0000
1976- 5	115.100	111.700	94.8000
1976- 6	115.700	113.200	94.5000
1976- 7	115.900	115.400	97.5000
1976- 8	117.600	116.100	99.3000
1976- 9	119.100	116.800	97.7000
1976- 10	121.300	116.700	94.6000
1976- 11	123.000	117.700	96.7000
1976- 12	124.600	118.300	100.700
1977- 1	127.900	119.200	104.100
1977- 2	129.200	119.800	104.700
1977- 3	130.400	121.700	106.300
1977- 4	133.800	122.600	108.300
1977- 5	134.800	124.700	109.900
1977- 6	136.200	125.300	110.400
1977- 7	136.400	126.400	111.600
1977- 8	137.000	126.300	114.100
1977- 9	137.800	127.900	114.300
1977- 10	138.400	130.300	117.000
1977- 11	139.000	131.800	120.100
1977- 12	139.800	132.900	123.300
1978- 1	140.600	134.000	130.600
1978- 2	141.400	135.900	130.600
1978- 3	142.300	137.600	129.500
1978- 4	144.400	138.700	127.200
1978- 5	145.200	140.100	126.000
1978- 6	146.300	141.300	128.800
1978- 7	147.000	141.700	133.800
1978- 8	147.900	142.600	138.000
1978- 9	148.500	144.900	141.100
1978- 10	149.200	147.200	145.500
1978- 11	150.200	148.900	143.700
1978- 12	151.500	152.700	145.900
1979- 1	153.700	153.400	148.700
1979- 2	155.000	154.300	151.700
1979- 3	153.200	151.600	154.900
1979- 4	158.900	153.100	158.500
1979- 5	160.200	155.100	157.100
1979- 6	162.900	157.500	163.000
1979- 7	170.000	160.300	176.900
1979- 8	171.300	162.600	175.000
1979- 9	173.000	166.100	173.200
1979- 10	174.800	167.800	172.300
1979- 11	176.300	170.900	173.600
1979- 12	177.600	172.100	180.100
1980- 1	182.000	175.300	190.200
1980- 2	184.500	179.300	194.700

Monthly Data

Entry	IB	TB	ES
1972- 1	5.06000	4.39000	5.31000
1972- 2	5.12000	4.39000	5.19000
1972- 3	4.87000	4.33000	5.66000
1972- 4	4.53000	4.25000	5.06000
1972- 5	5.06000	4.34000	5.49000
1972- 6	7.75000	5.67000	8.94000
1972- 7	8.40000	5.79000	8.91000
1972- 8	7.63000	5.86000	8.44000
1972- 9	7.56000	6.78000	8.56000
1972- 10	8.19000	7.00000	8.78000
1972- 11	8.50000	7.03000	9.94000
1972- 12	8.94000	8.45000	9.44000
1973- 1	10.1300	8.26000	10.5000
1973- 2	10.6300	8.19000	11.9400
1973- 3	9.94000	8.06000	11.4400
1973- 4	9.44000	7.77000	10.4400
1973- 5	9.25000	7.29000	10.0600
1973- 6	8.13000	7.02000	10.9400
1973- 7	11.6300	11.1600	14.5600
1973- 8	14.5000	11.2400	15.9400
1973- 9	13.2500	11.2000	14.8800
1973- 10	12.7500	10.9100	13.5000
1973- 11	15.6300	12.8300	16.2500
1973- 12	15.8100	12.7600	16.8100
1974- 1	16.3100	12.3700	19.3100
1974- 2	14.8100	12.1400	17.8100
1974- 3	15.5000	12.3000	19.4400
1974- 4	13.6300	11.8000	16.8100
1974- 5	12.8100	11.5000	14.9400
1974- 6	13.4400	11.5000	16.4400
1974- 7	13.4400	11.4700	15.5600
1974- 8	12.5600	11.5300	16.0000
1974- 9	11.7500	11.2400	15.3700
1974- 10	11.8100	11.1700	14.0000
1974- 11	12.5600	11.2400	15.5000
1974- 12	12.5600	11.2400	18.1200
1975- 1	11.8700	10.3800	12.6900
1975- 2	10.8100	9.99000	13.5600
1975- 3	9.94000	9.55000	12.1200
1975- 4	9.94000	9.42000	12.7500
1975- 5	9.94000	9.63000	11.1900
1975- 6	9.69000	9.68000	10.8100
1975- 7	10.5600	10.6600	11.1300
1975- 8	10.4400	10.6200	10.7500
1975- 9	10.6200	10.7300	11.3700
1975- 10	11.4700	11.7100	11.7500
1975- 11	11.2500	11.2600	11.9400
1975- 12	10.7200	10.8900	10.9400

Monthly Data

Entry	IB	TB	ES
1976- 1	9.44000	9.49000	10,5600
1976- 2	8.78000	8.76000	9.25000
1976- 3	8.50000	8.56000	9.81000
1976- 4	9.91000	10.1500	11.0000
1976- 5	11.4700	11.2600	12.3700
1976- 6	11.2200	11.2600	14.3100
1976- 7	11.2500	11.1500	13.0000
1976- 8	11.1900	11.2000	13.4400
1976- 9	12.8100	12.7400	17.1200
1976- 10	15.1900	14.9400	21.1900
1976- 11	14.6900	14.5100	16.3700
1976- 12	14.3700	13.9700	15.6900
1977- 1	12.4400	12.0500	13.7500
1977- 2	11.3100	11.0500	13.0000
1977- 3	9.12000	9.57000	9.25000
1977- 4	8.75000	7.64000	8.75000
1977- 5	8.12000	7.57000	12.5600
1977- 6	7.75000	7.60000	9.94000
1977- 7	7.62000	7.44000	8.37000
1977- 8	6.72000	6.52000	7.50000
1977- 9	5.84000	5.37000	6.19000
1977- 10	4.81000	4.53000	5.25000
1977- 11	7.50000	6.53000	7.37000
1977- 12	6.66000	6.39000	6.56000
1978- 1	6.47000	5.85000	6.87000
1978- 2	6.75000	6.07000	7.75000
1978- 3	6.94000	6.08000	7.62000
1978- 4	8.34000	7.12000	10.1900
1978- 5	9.44000	8.67000	10.2500
1978- 6	10.1600	9.49000	11.5000
1978- 7	9.97000	9.32000	10.7500
1978- 8	9.37000	9.03000	11.3700
1978- 9	9.69000	9.38000	13.0600
1978- 10	11.1600	10.5000	12.1900
1978- 11	11.9800	11.9100	13.8700
1978- 12	12.4400	11.9100	12.5600
1979- 1	13.1900	12.4600	13.5000
1979- 2	12.4400	12.6100	12.5000
1979- 3	12.1200	11.7800	12.0600
1979- 4	11.7200	11.6100	12.1200
1979- 5	11.8200	11.7900	11.7500
1979- 6	14.0700	13.7900	14.0600
1979- 7	14.2800	13.8100	14.6900
1979- 8	14.2500	13.8000	14.1200
1979- 9	14.1600	13.8200	14.1900
1979- 10	14.8200	13.9400	15.5000
1979- 11	16.6800	16.7700	16.6900
1979- 12	17.0700	16.6500	16.6900
1980- 1	17.2500	16.3900	17.6900
1980- 2	18.1900	16.8000	16.9700

Monthly Data

Entry	M_f	P_f	i_f
1972- 1	.604300	73.1000	5.06000
1972- 2	.610900	73.5000	4.97000
1972- 3	.618100	73.7000	5.53000
1972- 4	.625400	74.0000	5.00000
1972- 5	.634000	74.3000	4.63000
1972- 6	.641600	74.5000	5.31000
1972- 7	.649900	74.9000	5.66000
1972- 8	.658500	75.1000	5.50000
1972- 9	.664500	75.6000	5.94000
1972- 10	.673000	75.9000	6.03000
1972- 11	.682400	76.2000	6.00000
1972- 12	.690500	76.5000	5.91000
1973- 1	.696500	76.9000	6.63000
1973- 2	.706500	77.5000	8.44000
1973- 3	.713400	78.3000	8.69000
1973- 4	.724100	79.0000	8.25000
1973- 5	.733600	79.6000	8.63000
1973- 6	.738800	80.1000	9.06000
1973- 7	.745500	80.4000	11.4700
1973- 8	.755900	81.3000	11.5600
1973- 9	.762700	81.9000	10.4700
1973- 10	.769600	82.6000	9.19000
1973- 11	.771600	83.3000	10.4700
1973- 12	.782000	84.3000	10.1900
1974- 1	.788400	85.6000	8.88000
1974- 2	.798100	87.0000	8.63000
1974- 3	.807800	87.8000	10.0000
1974- 4	.822300	88.8000	11.6900
1974- 5	.824500	89.6000	11.8800
1974- 6	.829200	90.3000	13.5000
1974- 7	.835900	91.3000	13.5600
1974- 8	.840600	92.2000	13.9400
1974- 9	.844400	93.3000	12.1900
1974- 10	.852000	94.4000	10.1200
1974- 11	.863000	95.2000	10.6200
1974- 12	.870800	95.8000	10.0600
1975- 1	.876600	96.6000	7.44000
1975- 2	.883700	97.2000	7.31000
1975- 3	.890300	97.7000	6.97000
1975- 4	.896300	98.6000	6.81000
1975- 5	.903200	99.1000	6.06000
1975- 6	.915600	99.7000	6.75000
1975- 7	.921600	100.400	6.97000
1975- 8	.932200	100.600	7.34000
1975- 9	.940500	101.400	8.06000
1975- 10	.951200	102.200	6.81000
1975- 11	.964200	102.700	7.06000
1975- 12	.970900	103.100	5.87000

Monthly Data

Entry	M_f	P_f	i_f
1976- 1	.979500	103.900	5.37000
1976- 2	.989500	104.500	5.62000
1976- 3	1.00100	105.000	5.59000
1976- 4	1.00600	106.100	5.53000
1976- 5	1.01300	106.600	6.62000
1976- 6	1.02500	107.000	6.00000
1976- 7	1.03000	107.500	5.78000
1976- 8	1.03700	107.900	5.62000
1976- 9	1.04700	108.900	5.81000
1976- 10	1.05900	109.700	5.44000
1976- 11	1.06600	110.200	5.19000
1976- 12	1.07400	110.700	5.06000
1977- 1	1.08600	111.500	5.31000
1977- 2	1.09600	112.500	5.19000
1977- 3	1.10700	113.300	5.25000
1977- 4	1.11200	114.400	5.31000
1977- 5	1.11900	115.200	6.16000
1977- 6	1.13200	115.700	5.81000
1977- 7	1.14400	116.100	6.25000
1977- 8	1.15700	116.500	6.31000
1977- 9	1.16300	117.300	6.91000
1977- 10	1.17600	117.900	7.19000
1977- 11	1.18900	118.100	7.00000
1977- 12	1.20000	118.400	7.19000
1978- 1	1.21000	119.000	7.41000
1978- 2	1.22300	119.800	7.50000
1978- 3	1.23500	120.700	7.50000
1978- 4	1.25100	121.800	7.69000
1978- 5	1.26200	122.700	7.94000
1978- 6	1.27300	123.500	8.69000
1978- 7	1.28500	124.200	8.41000
1978- 8	1.29500	124.700	9.00000
1978- 9	1.30700	125.600	9.53000
1978- 10	1.31300	126.400	11.4100
1978- 11	1.32900	126.800	11.7800
1978- 12	1.34700	127.200	11.6900
1979- 1	1.35900	128.300	10.4400
1979- 2	1.36900	129.400	10.6200
1979- 3	1.37200	130.500	10.6600
1979- 4	1.38600	131.900	10.8700
1979- 5	1.39500	133.200	10.5600
1979- 6	1.40300	134.300	10.5900
1979- 7	1.42000	135.700	11.3400
1979- 8	1.43400	136.500	12.1900
1979- 9	1.44700	137.900	12.8700
1979- 10	1.45600	139.300	15.4100
1979- 11	1.46500	140.200	14.3100
1979- 12	1.46100	141.500	14.5000
1980- 1	1.50100	143.700	14.4100
1980- 2	1.50600	145.400	16.9700

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